SZTE Egyetemi Könyvtár
Egyetemi Gyűjtemény
3
HELYBEN
OLVASHATÓ

TISCIA monograph series

# Ecological aspects of the Tisa River Basin

10 years anniversary regional conference
21nd - 24th March 2002.
Târgu-Mures, Romania

Editors
A. Sárkány-Kiss and J. Hamar

TISCIA
monograph
series
6

Târgu Mures-Szeged-Szolnok
2002

TISCIA monograph series

SZTE Egyetemi Könyvtár
Egyetemi Gyűjtemény
3

HELYBEN
OLVASHATÓ

B 198430

TISCIA monograph series
volume 6.

# Ecological aspects of the Tisa River Basin

10 years anniversary regional conference
21nd - 24th March 2002.
Târgu-Mureş, Romania

Editors
A. Sárkány-Kiss and J. Hamar

Târgu Mureş–Szeged–Szolnok
2002

ENVIRONMENTAL PARTNERSHIP FOR CENTRAL EUROPE CONSORTIUM

Project financed by Fundația pentru Parteneriat Miercurea Ciuc
Hungarian Environmental Parnership Foundation Budapest
Project No. T-RO01-3

SZTE Egyetemi Könyvtár SZEGED 3.

SZTE Egyetemi Könyvtár
J910021490

Edited by: Pro Europa League & Tisza Klub

PRO EUROPA
Liga Pro Europa
4300 Târgu Mureş, P.O. Box 1-154, Romania

Tisza Klub for Environment and Nature
5001 Szolnok, pf. 148, Hungary

Editorial board:
*László Gallé*
*Marian Traian Gomoiu*
*László Körmöczi*
*Dan Munteanu*
*László Rákosy*

ISSN 1418-0448
ISBN 963 204 619 6

B 198430

# PREFACE

We have been exploring the rivers belonging to the Tisa River Basin for ten years, our work having been organized by the Tisza Klub, Szolnok, Hungary and the Pro Europa League Târgu-Mureş, Romania. The two nongovernmental organizations signed a cooperation agreement on 27th April 1991. The most important objective of the cooperation was "the creation of a scientific database, with special regard to the common river valleys" and "the achievement of environmental and educational aims". For the survey of the common rivers we have recruited a multidisciplinary work-team of Romanian and Hungarian experts. The germinating power of the work has made our professional and personal relationship closer and closer. With a strong belief in our joint power, we have made bolder and bolder plans. More and more Romanian, Hungarian, Ukrainian and Slovakian colleagues and social organizations have been invited to cooperate.

Our surveys have been extended to the Upper Tisa and its numerous tributaries.

Working with nongovernmental organisations made us possible to invite well-known specialists from every country from the Carpathian Basin. We have revealed the real condition of the surveyed rivers, we have drawn the attention of the executive and supervising state institutions to the endangered river sections, to the natural riches we intend to protect, and we have elaborated a matter-of-fact documentation of environmental protection. Our results were published in the first four volumes of the Tiscia Monograph Series, with studies about the Mureş/Maros, the Someş/Szamos, the Criş/Körös and the Upper Tisa Rivers. There is an upcoming volume about the Bodrog River, too.

After eleven years of working together we felt that the time has come to summarize and analyse together our results, to draw the main consequences based on knowledge of more than ten rivers and to list the main tasks for nature- and environment protection. That is why we organised the "Conference of the Tisa River Basin Experts" on March 22-24, 2002. We addressed three questions to participants in the conference invitation:

- Why are our rivers ill?
- Are we taken serious by the executive bodies?
- How to go further?

The answers for the first question were given by the contributions presented at the conference and in this volume, giving substantial completion of the studies already published.

The fact that the specialists` warning call is still inconvenient to executive bodies was clearly shown by the absence of their invited representatives. This gives the answer to our second question. We believe that the new EU Water Framework Directive, which obliges the members to treat the rivers as habitats, hopefully will bring serious changes in EU-member aspirant countries, too.

The "How to go further" question is partially answered by the papers published in this volume, when they present new methods of ecological water-qualification or discuss theoretical issues like "Flood-plain research at different spatial scales". The participants agreed that after compiling the first basic database of river valleys it is time for well designed monitoring schemes to follow the changing tendencies. In the same time, we should also concentrate on revealing cause-consequence relationships. The planning and execution of this work cannot be done properly by nongovernmental organisations. We were delighted to see that our work was more and more supported by universities and research centres like the Ecology Department of the Szeged University, the Uzgorod University, the Debrecen University, the Babeş-Bolyai University, the Lucian Blaga University (Sibiu), the University of Oradea, the Grigore Antipa Museum, the Fish Culture Research Institute at Szarvas, Environmental Agencies from Szolnok, Debrecen and Gyula.

The river research initialized by the nongovernmental organisations stimulated a series of cooperations between the institutes of neighbour countries:

- between 1999-2001 during a two year research project intitled *"Investigation of the Natural Resources of the Mureş River for Sustainable Development"* (Research Support Scheme of the Open Society Support Foundation) a common eight member research team of the Babeş-Bolyai and Debrecen University surveyed the whole lenght of the Mureş/Maros river, registering the changes occured since the 1991 survey.

- the „Research of the habitat-corridors on Tisa river and its tributaries" project is founded by the Hungarian Environment Protection Ministry and it is listed among the projects coordinated by the European Centre for Nature Conservation.

- a complex research programme to study the freshwater living communities exposed to cyanide and heavy metal pollution in the Lăpuş/Lápos, the Someş/Szamos and the Tisa rivers, supported by the Hungarian Academy of Sciencies and the Arany János Foundation of the Hungarian Academy of Science.

- Investigation of the Risk of Cyanide in Gold Leaching on Health and Environment in Central Asia and Central Europe (Inco Copernicus Project).

We woud like to thank the help of those specialists who were not participating directly in our river expeditions but followed our work and gave us advice: Dr. László Gallé, Head of Ecology Department at Szeged University; Prof. Dr. Marian Traian Gomoiu, Academician, Deputy General director of the National Institute of Marine Geology and Geoecology, professor of the Ovidius University Constanţa; Dr. Dan Munteanu, Academician, BirdLife Romania; Dr. György Dévai, Head of the Ecology Department at Debrecen University and Dr. János Tardy. Special thanks are addressed to Professor László Gallé and Dr. László Körmöczy who offered us the possibility to publish our results in volumes of the *Tiscia monograph series*.

ANDREI SÁRKÁNY-KISS
Pro Europa League
Târgu Mureş, Romania

JÓZSEF HAMAR
Tisza Klub
Szolnok, Hungary

# FLOOD-PLAIN RESEARCH AT DIFFERENT SPATIAL SCALES

*László Gallé*

**Abstract**

This paper presents the main philosophy, aims and some preliminary results of the joint Rumanian—Hungarian ecological project carried out in the terrestrial habitats of River Mureş/Maros flood plains. The studies, scoping different spatial scales from the microcosms to the regions, have revealed the specificities of plant communities in very small patches (ant mounds), the role of an ant supercolony in structuring spatial pattern of the whole ant community, the differential effect of exogenous factors on the habitat selection of plant and different invertebrate assemblages, the restricted potential corridor function of the terrestrial habitats along River Mureş/Maros, and the scale-dependence of the faunal and community similarities.

**Keywords:** River Mureş/Maros, ecological communities, community organization, scales, scale-dependent patterns.

## Introduction

There are two main paradigm shifts in the contemporary ecology. One is the recognition and acceptance of random processes and non-equilibrium dynamics (Pickett and White 1985, Diamond and Case 1986, Gallé 1998 and the citations therein), which includes the application of stochastic models, and the other is the change of the traditional spatio-temporal habitat scale of the classical ecological studies to both smaller (microcosm) and larger (landscape, region) directions (Lucas 1992, Haines-Youing et al. 1993, Farina 1998, Margóczi 1998, Gaston and Blackburn 2000). Both views opened new perspectives for the ecological researches and their applications. Although the different patterns, processes and mechanisms of different ecological (supraindividual) biological units (e.g. populations, communities etc.) have been intensively studied and/or interpreted at different scales, the nomenclature remained very poor and besides the few names already given, such as metapopulation, sigma-communitites etc., many are yet missing (Table 1). The scale enlargement has been manifested in such theories and fields of studies, as interdemic selection, the dynamics of the metapopulations, metacommunities and sigma-communities (Wilson

1975, Hanski and Gilpin 1997, Hanski 1999). As an indication of the turn of interest to the macroscales, even new disciplines have appeared, which deal with the large-scale ecological research and conservation management (e.g. landscape ecology, macroecology, Haines-Youing et al. 1993, Farina 1998, Gaston and Blackburn 2000). The application of the large-scale approaches is especially important for the river research in the Carpathian Basin. These sorts of approaches bring community and population ecology, faunistics and floristics, as well as biogeography closer to each other. At larger spatial scale, we have to emphasize the importance of the biotics (floristics and faunistics), which has been a neglected discipline for decades and it should get back its own right, as important representatives of the main sciences studying essential aspects of biodiversity.

In this paper we present the main objectives of the joint Hungarian-Rumanian terrestrial ecological project on the River Mureş/Maros.

The main philosophy of the Mureş/Maros joint ecological program of Cluj and Szeged universities is to study patterns, possible processes and their probably mechanisms at different spatial scales and to try to find the connections of the scales by interpreting their co-ordinatedness and complementarity at the terrestrial habitats along the River (for the first results, see Margóczi et al. 2000a, Gallé et al. 2000).

**Table 1. Ecological objects at different scaling levels. The mark ◉ shows the scale at which the object in question has been traditionally studied. The question marks show those scales at which the specified unit is studied, but no name has been given to that. The name biogeocenosis is applied instead of widely used ecosystem because the letter term should be restricted to the cases, when systems analysis is done (see Juhász-Nagy 1986).**

| Unit | Scale | | | | |
|---|---|---|---|---|---|
| | **Micrcosm** | **Local (habitat)** | **Landscape** | **Region** | **Global** |
| **Biogeocenosis** | | ◉ | ? | biom | biosphere |
| **Community** | | ◉ | meta-, sigma- | ? | ? |
| **Population** | | ◉ | meta- | ? | species |
| **Group** | ◉ | super- | | | |
| **Individuum** | ◉ | ◉ | | | |

**Table 2. Habitat attributes for characterization of study plots for invertebrates at Voslobeni, Upper-Mureş/Maros (after Gallé et al 2000)**

| Group | Attributes | No of categories |
|---|---|---|
| **1. Habitat architecture (19 scores)** | 1.1. moisture degree | 1 |
| | 1.2. total cover of higher plants, mosses and debris | 3 |
| | 1.3. moss and debris thickness | 1 |
| | 1.4. vegetation cover at 0-5, 5-15, 15-30...100-300, >300 cm | 8 |
| | 1.5. maximum heights of plants | 1 |
| | 1.6. no of stones | 1 |
| | 1.7. no and condition of twigs on the ground | 2 |
| | 1.8. height and cover of moss mounds | 2 |
| **2. Vegetation composition** | 2.1. coverage of higher plant species | 155 |
| **3. Soil** | 3.1. different soil parameters (pH, hardness, water content) | 3 |

## Within-habitat scale

The first, smallest spatial levels of the investigations are the within-habitat ones, e.g. microcosms, between microcosms and habitats (see Table 1).

At the level of microcosm, among others, we studied the distribution of higher plants on the nests of *Lasius flavus* F. and their surroundings. *L. flavus* mounds act as very small islands (in order of $10^1$ cm in both diameter and height, as a rule) for the vegetation. Although obtaining their plants from the surrounding biota, the species composition and frequency distribution of the ant mound plant assemblages significantly differ from the neghbouring ones (Fig. 1, after Margóczi et al. 2000b). On the ant mounds the plants cannot avoid each other's influence because of the small size of these microcosms (Margóczi et al. 2000b).

Another example of within-habitat studies is the research on the distribution of ant nests, the within-colony distribution of ant individuals and the structuring role of ecological interactions, especially interspecific competition in the spatio-temporal patterns of ant populations in the supercolony of *Formica exsecta* F. The individual nests of the huge supercolony covering more than 1 sq. km are more or less randomly dispersed (Fig. 2). The effect of the *F. exsecta* on the spatio-temporal distributional and activity patterns of the other ant populations was studied by bait experiments and mini-pitfall-trap sampling, studying the density and activity of ants other than *F. exsecta* as a function of the density of *exsecta* individuals. The preliminary results show, that the role of *exsecta* in structuring the ant community if weaker than it was expected (Gallé and Markó 1999, Markó, Mabelis and Gallé in preparation).

## Landscape scale

At the level of landscape (between-habitat scale), different ecological assemblages (i.e. plants, grasshoppers, spiders, ants, beetles and snails) of different habitats are compared within the same regions in details. These studies have been carried out in four regions by the River Mureş/Maros, i.e. at the upper stream (near Voslobeni, Roumania), in the vicinity of Zam and Deva (Roumania), at Arad-Pecica (Roumania) and at Maroslele, near Szeged (Hungary).

Besides sampling plant and invertebrate assemblages (e. g. wolf spiders, ants, grasshoppers ground beetles), the possible background factors (see Table 2) and their assumed effects were also assessed. As an example, we show here the results obtained at Voslobeni, where we selected seven study plots, which represented different habitat types (Margóczi et al 2000a, Gallé et al 2000). At these plots, nine plant assemblage types were distinguished (by Braun-Blanquet system, Margóczi et al 2000a). The Principal Coordinate Analysis (PCoA) of the vegetation showed that the plant assemblages of the region form four groups such as (1) wetlands characterized by *Carex* species; (2) meadows of *Molinietum coeruleae* plant associations; (3) dry pastures and (4) transitional vegetation *(Caricetum flavae juncosum subnodulosi)* between (1) and (2). The picture on the basis of different animal assemblages is not so unequivocal.



SZTE Egyetemi Könyvtár SZEGED 3.

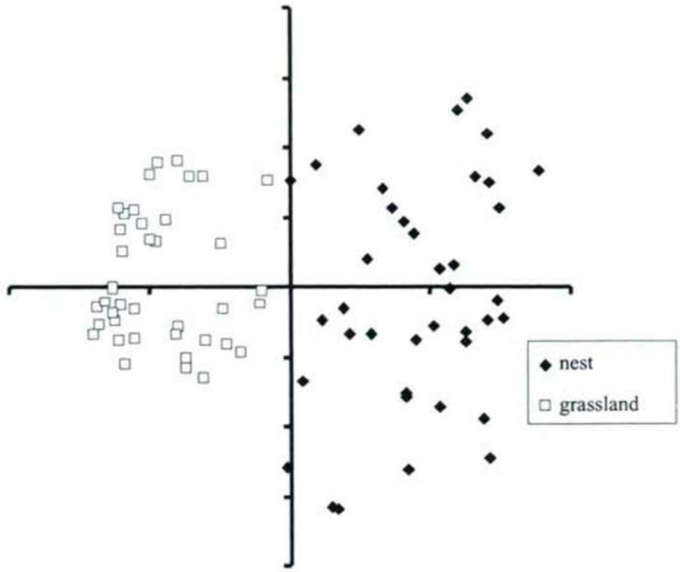



**Fig. 1. Principal Coordinate scattergram (Jaccard distance function) of the vegetation on *Lasius flavus* mounds and in the neighbouring grassland at Voslobeni (After Margóczi et al. 2000a).**

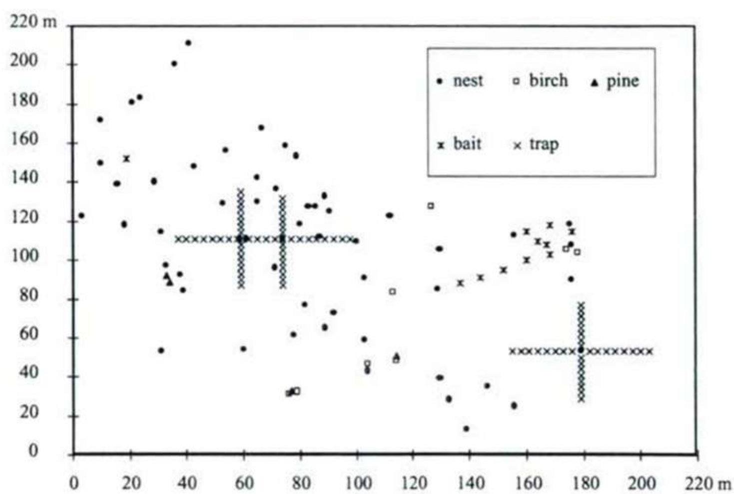



**Fig. 2. Distribution of the individual nests of a *Formica exsecta* supercolony in a pasture at Voslobeni.**

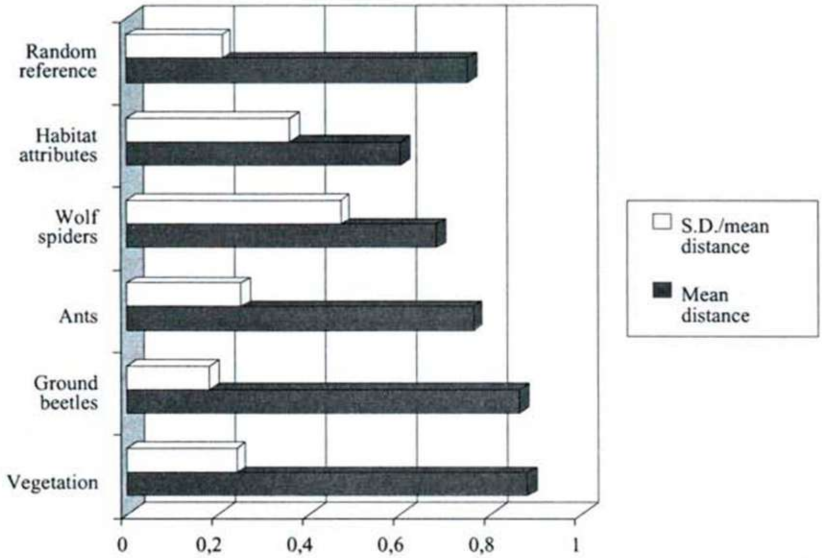



**Fig. 3. Average habitat distances and their coefficients of variation computed on the basis of habitat attributes (Table 2), different assemblages and their random reference**

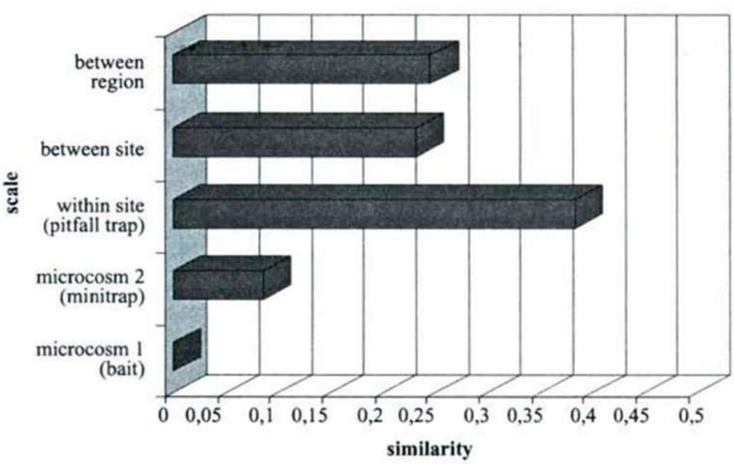



**Fig. 4. Similarity values of ant assemblages and faunas as a function ofspatial scaling levels: at two small, within supercolony (microcosm 1 andmicrocosm 2) scales; at habitat (within site) scale; at landscape (betweensite) scale and at regional (between region) scale, respectively.**

Three habitat groups can be distinguished on the basis of ground beetle and wolf spider assemblages from their PCoA scattergrams, but different plots form groups. In beetles' scattergram, however, no well-defined groups are formed (Gallé et al 2000).

We interpreted the indication of the heterogeneity of the landscape by the different assemblages at Volobeni as of the average habitat disssimilarities (Bray-Curtis distance function, Podani 1997, Tóthmérész 1993) computed on the basis of the composition of different assemblages. The most sensitive indicators of landscape heterogeneity are the vegetation and the ground beetles (Fig. 3), whereas the distances on the basis of ant and wolf-spider assemblages do not exceed the values computed from fictive, randomly assembled communities.

A non-parametric correlation analysis shows that there is close correlation between the following assemblages and the groups of habitat scores: (1) vegetation composition and soil properties; (2) vegetation composition and Carabid beetles; (3) ants and habitat architecture (see also Gallé 1991, 1999, Gallé et al 1993, 1998); (4) ants and wolf spiders; (5) wolf spiders and habitat architecture; (6) ground beetles and vegetation composition. According to these results, those groups of habitat attributes could be assumed to be responsible for the composition of the ecological assemblages, with which they are correlated. Therefore, we can conclude that the composition of different assemblages are presumably conducted by different exogenous factors, the results of which are indicated by the above-mentioned response to the habitat heteromorphy.

**Regional scale**

At regional scale, our main aim has been to compare the above-mentioned four complexes of sites and to carry out faunistical "scanning" studies between these regions. At this level, we hoped to obtain results on the ecological corridor function of the River Mureş/Maros valley, too.

For the regional level comparison, the first question by an ecologist could be that whether an ecological pattern or mechanism is scale dependent. As an example, we demonstrate here the comparison of similarities of the ant (Formicoidea) assemblages/faunas at microcosm, within site (habitat), between habitat and regional scales, respectively (Fig. 4). The data originated from the following field samplings: (1) *microcosm 1*: bait experiments were conducted to follow the circadial rhythms of ants at very small spatial scale; (2) *microcosm 2*: data from mini pitfall traps arranged in 50x50 cm grids and employed to reveal the small spatial scale differences in the penetrated foraging territories of different species; (3) *within site (habitat) scale*: the data are from pitfall traps arranged in 5x5 m grids in the sampled sites and the catches of the individual traps is compared with similarity measurement; (4) *between site level*: comparison of the data from different sites within a landscape complex (e.g. within Vaslobin or Maroslele district) and (5) *between region level*: a comparison of the ant fauna of the different regions.

As it is seen on Fig. 4, no linear scale-dependent trend is observed, but there is a similarity maximum at within site scale. The low similarity values experienced at microcosm level are resulted in by the segregation in the territories of the different species and also by the circadian activity differences (in the case of baits) in the presence of a supercolonial species. The high average similarity at within site shows that the sampled habitats are more or less homogeneous. The between site difference indicates the differences of sampled sites (the design of sampling involving different habitat types was our original intention in this study). One could expect even greater dissimilarities at the larger, between-region level, brought about by the geographical scale differences. The results, however, do not meet this expectation, probably because there are similar habitat types of the different studied regions, where the populations of the same, mostly widely distributed species were found. The alternative hypothesis could be that the habitat stripes along the river act as "ecological corridors", resulted in similar withis-stripe faunas.

The ecological corridor and the ecological network are among the recent and fashionable buzzwords both in ecology and conservation biology. Rivers, both their water bodies, and the terrestrial habitat complexes of the flood plains are *a priori* regarded to be ecological corridors, as a rule. If we define ecological corridors as such stripe-like habitat, which promote the migration, the dispersion, and the distribution of plant and animal species, it is clear that no any habitat strip is ecological corridor *per se*. It depends on the studied ecological objects i.e. populations or communities, if a habitat strip is used as corridor or not. Therefore, the term ecological corridor is plural, similarly to the ecological environment. The corridor function of the flood plain of River Tisa has been demonstrated on plants, grasshoppers, ants, snails, birds and ground beetles (see Gallé 2002, Gallé et al 1995 and the citations therein). Since the flood plain is a complex of different habitat zones and ecological communities along River Tisa, there is a composed system of potential corridors, differently promoting the migration and distribution of different species either to the North or to the South. Besides these functions, the terrestrial habitats by the River, Tisa flood plain also acts as core areas for several populations and communities and promote the recolonization of these ecological units in habitats island outside the flood plain. In the case of River Mureş/Maros, the corridor role is not unequivocal, although the very first paper dealing with role of flood plains and especially floods themselves, as the promoters of insect migration and distribution was published on the beetles by the River Mureş/Maros (Erdős 1935). As one side we cannot dispute the results concerning the faunal (and probably also the floral) distribution by the flood by direct drive, the great differences of the fauna at the upper and lower streams of the river, the different geographical character of the different regions and especially, the interruptedness of the stripe-like habitats at the middle parts of the flood area, where the cultivated fields are adjacent to the riverbanks.

The ecological communities in the inundated part of the flood plain are regularly exposed to the disturbing effects of repeating floods and the processes of recovery result in a complicated dynamics, which can be described with the catastrophe theory. The recolonization of the formerly flooded sites takes place from the higher refuge, from the trees and from the unflooded areas outside. Both the longitudinal migration and distribution along the river ("corridor function") and the transversal migration from to the flooded area (core area function and recolonization) form a complex, rather complicated dynamics of the riversides' biota. As our preliminary results have shown, however, in the case of River Maros, the corridor function is much more restricted.

## References


Farina, A. (1998): *Principles and Methods in Landscape Ecology.* — Chapman & Hall, London.

Erdős, J. (1935): *Maros torkolatának árvízi és ártéri bogárvilága biológiai szempontból (The beetle fauna of floods and flood plains at the outlet of River Maros).* — Thesis, Szeged pp. 84

Gallé, L. (1998): Ekvilibrium és nem-ekvilibrium koegzisztencia életközösségekben (Equilibrium and non-equilibrium coexistence in ecological communities). In: Fekete G. (ed.): *A közösségi ökológia frontvonalai (Frontiers of Community Ecology).* —

Gallé, L. (2002): A Tisza-mente ökológiai és természetvédelmi jelentősége (The ecological and conservational significance of Tisa flood plain). In: Rakonczai, J, (ed.): *A Tisza vízgyűjtője, mint komplex vizsgálati és fejlesztési régió (Tisa Catchment Area as a Region for Complex Research and Management).* — Tisza Vízgyűjtő Programrégió, Szeged, 75-81.

Gallé, L., Margóczi, K., Kovács, É., Györffy, Gy., Körmöczi, L., Németh, L. (1995): River valleys: Are they ecological corridors? — Tiscia, 29, 53-58.

Gallé, L., Körmöczi, L., Hornung, E., Kerekes, J. (1998): Sructure of ant assemblages in a Middle-European successional sand-dune area. — Tiscia, 31, 19-28.

Gallé, L., Gallé, R., Markó, B., Mikó, I., Sárkány-Kiss, A. (2000): Habitat correlates of ground invertevrate assemblages in a flood plain landscape complex. In: Gallé, L., Körmöczi, L. (ed.): *Ecology of River Valleys.* — Dept. Ecology, Univ. Szeged, Szeged, 31-36.

Gallé, L., Györffy, Gy., Hornung, E. (1982): Flood as an ecological perturbation of epigeic animal communities I. Some preliminary hypotheses on the application of catastrophe theory by evaluating some Mártély-Körtvélyes data. Tiscia, 17, 155-162.

Gaston, K. J., Blackburn, T. M. (2000): *Pattern and Process in Macroecology.* — Blackwell, Oxford.

Hanski, I. (1999): *Metapopulation Ecology.* — Oxford Univ. press, Oxford

Hanski, I., Gilpin, M. E. (1997): *Metapopulation Biology Ecology, Genetics and Evolution.* — Academic Press, San Diego

Gurney, W. S. C., Nisbet, R. M. (1998): *Ecological Dynamics.* Oxford University Press, New York.

Haines-Young, R., Green, D. R., Cousins, S. H. (ed.)(1993): *Landscape Ecology and the GIS.* — Taylor and Francis, London.

Juhász-Nagy, P. (1986): *Egy operatív ökológia hiánya, szükséglete és feladatai (Shortage, Need and Duties of an Operational Ecolgy).* — Akadémiai Kiadó, Budapest.

Lucas, P. H.C. (1992): *Protected Landscapes.* — Chapman & Hall, London.

Margóczi, K. (1998): *Természetvédelmi Biológia (Conservation Biology).* — JATEPress, Szeged.,

Margóczi, K., Drăgulescu, C., Macalik, K. (2000a): Vegetation description of the habitat complexes along the Maros (Mureş) River I. In: Gallé, L., Körmöczi, L. (ed.): *Ecology of River Valleys.* — Dept. Ecology, Univ. Szeged, Szeged, 37-42.

Margóczi K., Németh A. Markó, B., Gallé, L. (2000b): Egy különleges szigetvilág: hangyafészkek növényzete (A special archipelago — vegetation of ant nests)– V. Magyar Ökológus Kongresszus, Debrecen. Kivonatok (Abstracts), 268. o.

Markó, B., Gallé, L. (2000): A Formica exsecta Nyl. szuperkolónia hatása a hagyaközösségek térszerkezetére (The effect of Formica exsecta Nyl. supercolony on the spatial sructure of an ant community).— Szünzoológiai Szünpózium, Előadáskivonatok, Budapest, 18.

Nisbet, R. M., Gurney, W. S. C. (1982): Modelling Fluctuating Populations. - Wiley, Chichester.

Pickett, S. T. A., White, P. S. (1985): *The Ecology of Natural Disturbance and Patch Dynamics.* — Academic Press, Orlando.

Podani, J. (1997): *Bevezetés a többváltozós biológiai adatfeltárás rejtelmeibe (Introduction to the Mutivariate Analysis of Biological Data).* - Scientia, Budapest Scientia, Budapest, 11-33.

Tóthmérész, B. (1996): *NuCoSa: Programcsomag botanikai, zoológiai és ökológiai vizsgálatokhoz (NuCoSa: Progrma Package for Botanical, Zoological and Ecological Studies).* - Scientia, Budapest.

Wilson, E. O. (1975): *Sociobiology The New Synthesis.* Belknap, Harward, Cambridge, Mass.

LÁSZLÓ GALLÉ
Department of Ecology, University of Szeged
Szeged Pf. 51, H-6701, Hungary
galle@bio.u-szeged.hu

# THE CAUSES OF CATASTROPHIC FLOODS IN THE TRANSCARPATHIAN REGION AND THE SYSTEM OF ECOLOGICAL PROPHYLACTIC MEASURES FOR THEIR PREVENTION

*S. M. Stoyko*

**Keywords:** floods, layer shifts, carst processes, mud flows, water basin, ecohydrological system.

The greatest floods in the XX-th century occurred on November 4-8, 1998 in the Transcarpathians, in the upper reaches of the Tisa and its tributaries – the Teresva, the Rika, the Borzhava, as well as in the basin of the river Latorytsia. These floods were accompanied by such natural disasters as mud flows, structural and layer shifts, plane and bank erosion and carst processes. All of these increased essentially the material losses. According to official data, 269 villages populated by 40790 people suffered from the floods. There were 1426 houses ruined fully and 1347 houses partly damaged. The 2887 houses needed capital repair and the 187 populated areas were deprived of telephone communication.

In the mountain villages of Tyachiv district there were 241 families that had to leave their dwellings as a result of layer shifts, and about 300-350 houses are still in dangerous zone as to the shifts and under the control of geologists. 100,000 hectares of agricultural lands, including the 70,000 hectares of arable land were flooded in Prytysianska lowland, as well as in the plain villages within the basins of the Teresva, Tereblya, Rika, Borzhava and Latorytsia rivers.

Water chaos damaged 20 big bridges of 876 m lenght and 254 km of highways. 680 special shores were destroyed in the beds of rivers. In the basin of the Teresva, near the villages of Kryve, Neresnytsia, Pidplesha, Krasna and Lopukhovo dozens of km of narrow-gauge railways were damaged, many railway bridges were undermined. The railroad was put out of action for a long time.

During this ecological disaster 17 persons were lost, the general economical losses exceeded 400 million hryvnas, to say nothing of the cost of hundreds of thousand cubic meters of washed out brown-soil grounds and agricultural lands, depreciated by shifts.

The ecological disaster attracted the public attention in many countries of Europe, America and Asia, which rendered the humanitarian and technical assistance to the flood's victims. Ukrainian President and the Head of the Government visited the

Transcarpathian region for several times to speed up the liquidation of flood aftermath and to help the people.

The problem of conquering floods and other natural disasters has an interstate importance. The largest tributary of the Danube – the Tisa flows through the transboundary zone of Ukraine, Romania and Hungary. Its length is 201 km within the Transcarpathian region and totals – 966 km. Transcarpathian rivers such as the Latorytsia and the Uzh flow down into the river Bodrog on the territory of Slovakia. Numerous oil and gas pipelines, the pipes for chemical products and ethylene, high-voltage electrical lines are laid through the Ukrainian Carpathians. There are also the railways and highways of international significance there. Therefore it is important to ensure an ecological balance for normal functioning of these communications in the region.

Comparative ecological research shows that the character and the scale of floods is conditioned by a complex of interacting natural and anthropogenic factors.

Among the natural factors the most important is the unfavourable hydro-meteorological situation: the quantity of precipitation exceeds the norm; the duration, intensity and area of rainfall; the sudden melting of snow in early spring or late autumn; the character and density of hydrological net.

It should be noted that the Carpathians are situated in the semi-humid and humid climatic zone. In Chop (102 m above sea level) falls 700 mm of vertical precipitation per year, at the meteorological station Ruska Mokra (640 m a.s.l.) in Gorgan Mts. it reaches 1600 mm. To this quantity we should add about 200 mm of horizontal precipitation from moisture condensation of fog and hoar-frost in the forests [16]. Hydro-net in Transcarpathians includes 9426 rivers and streams 19,793 km long. Here is the highest density of waterways in Ukraine – 1.7 km per km$^2$.

Flood processes depend also on the characters of water basin surface – steepness of the slopes, dismemberment of the relief, thickness of the pedosphere, depth of geological layers.

Due to such unfavourable ecological situation dangerous floods happened in the Carpathians in the past too, when the anthropogenic impact onto natural landscapes was insignificant. According to contemporary records and historical data, floods were registered in the basins of the Tisa, the Dnister and the Prut in 1700, 1730, 1864, 1887, 1895, 1900, 1911, 1913, 1926, 1927, 1933, 1941 [1,5].

At the beginning of the XXth century an especially dangerous flood took place in Transcarpathians on the Tisa on July 10-11 1913, when the water level in the centre of Tyachiv reached 120 cm (it is marked on the monument of L. Kossuth). In 1914, despite of the war, Hungary built a strong dike on the right bank of the Tisa to protect populated areas.

In the 1930-ies the village Vylok in Berehovo district suffered from the flood and the Czechoslovakian government built a similar dike.

Ecological stability in the basins of mountain rivers and their normal hydrological regime depend greatly on the index of forestation, the character of vegetation cover and anthropogenic changes in its structure. From all types of vegetation, forest ecosystems, due to the multi-layer structure of its over- and underground parts and high productivity, have the highest ecostabilizing importance. The efficiency of water-protective function of forest ecosystems depends on the index of afforestation within the water basin, the age, the dendrological composition, the vertical structure, productivity, sanitary condition of phytocoenosis, character of the layer and physical properties of forest soils.

According to the data of long-time research of O.V.Chubaty [13] at the forest hydrological station in Svalyava (219 m a.s.l.), with annual precipitation of 965 mm, the ripe beech forest holds 25.1% of precipitation during the year, and the rest of 74.9% gets under its floor. On the northern macro-slope of the Carpathians at the station Khrypeliv (850 m a.s.l., 1094 mm of precipitation) spruce forest hold 36.9% of precipitation, and 63.1% of it goes under the floor. With the increase of afforestation index on 1% of the area, an average river flow is increasing by 9.4 – 11.9 mm.

During the last centuries undesirable quantitative and qualitative changes took place in the forest formations in the Carpathians and then influenced essentially the ecological stability of the natural environment. The area of oak forests has decreased by 64,000 ha, the beech forests by 93,000 ha, and the fir forests by 36,200 ha. On the other hand, the area of spruce forests (mostly monocultures) has increased by 298,300 ha [3,7,8]. The area of post-forest pastures has increased by 331,000 ha and the area of post-forest hayfields by 213,000 ha [4]. There are about 60,000 ha of anthropogenic bushes and 113,000 ha of badlands in the Ukrainian Carpathians. The general afforestation degree in four Carpathian regions in 1973 was 20.16% in the plains and 53.52% in the mountain parts [9].

Essential changes in the forest stock of the Carpathians had taken place in economically difficult post-war years. During 1947-1957 73 million $m^3$ of wood was cut there and 20% of the forest covered lands was bared. Fig.1 and 2 show the dynamics of the main use and afforestation in Transcarpathians in the post-war times. These significant territorial changes in ripe forests had negative impact on the hydrological condition of mountain rivers too, and disastrous floods became more frequent. They were marked in 1947, 1948, 1955, 1957, 1959, 1964, 1969, 1970, 1974, 1977, 1980, 1982, 1992, 1993, 1997 and 1998 [5,9,10,12].

Especially unfavourable hydrological situation was in the Transcarpathians in the autumn of 1998. It caused immense floods, ground shifts and mud flows. During August – October the precipitation at the meteorological stations in Transcarpathians reached 1.2 – 2 monthly quotas and the over-wetted ground did not hold the excessive moisture (Fig.3). At the beginning of November 1998 an atmospheric front passed through the Carpathians causing the formation of micro-cyclons in the Ukrainian Carpathians. As a result, the total quantity of precipitation was 45-75 mm on November 4-5 in the basins of the Latorytsia, the Borzhava and the Teresva; in the upper basin of the Tisa it was 90-120 mm, and in the upper waters of the Rika 207 mm (Fig.4). Daily amount of precipitation reached monthly norm and in some places 1.5 of norm.

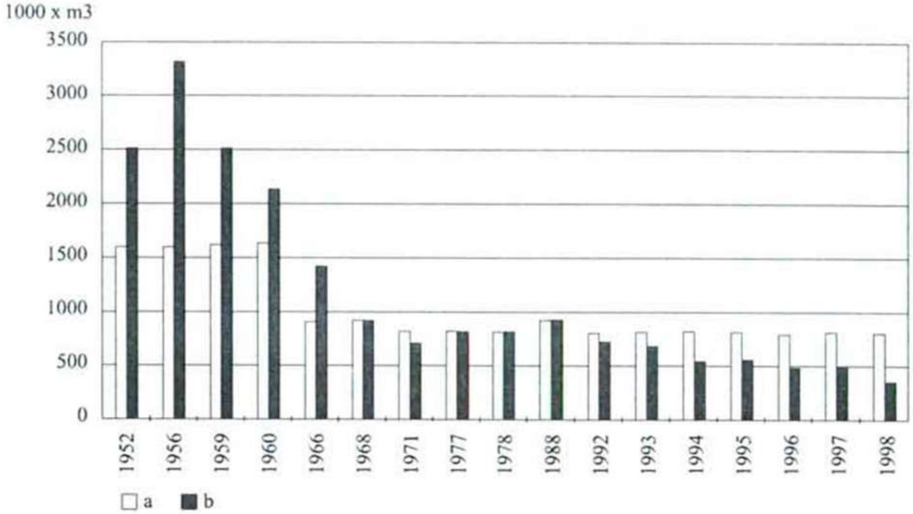



**Fig. 1. The dynamics of real clear cutting in forestry in the comparison with ecological grounding cutting (1952-1998) (here and on the fig. 2 – according the date of Forestry direction). Symbols indicate: *a* – ecological grounded clear cutting, *b* – real cutting**

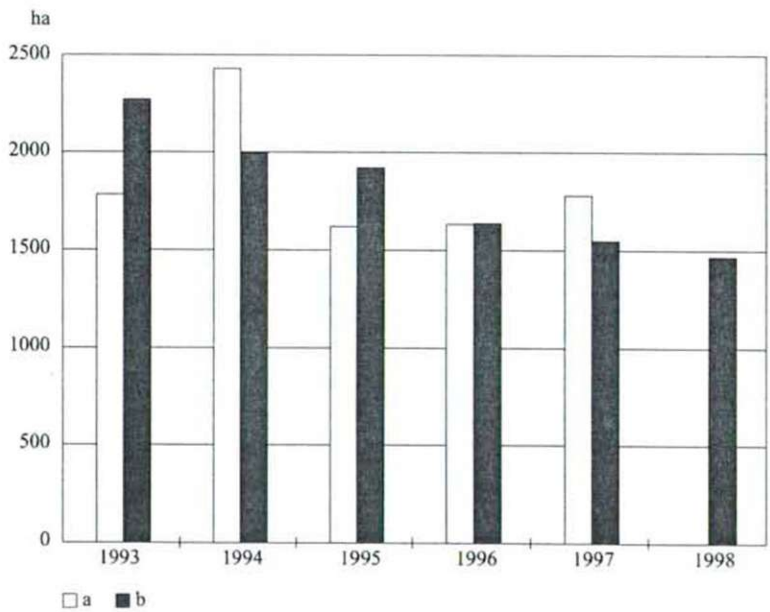



**Fig. 2. The dynamics of forestation in comparison with area of clear cutting in forestry in the 1993-1998 period. Symbols indicate: *a* - the area of clear cutting, *b* - the area of forestasion.**

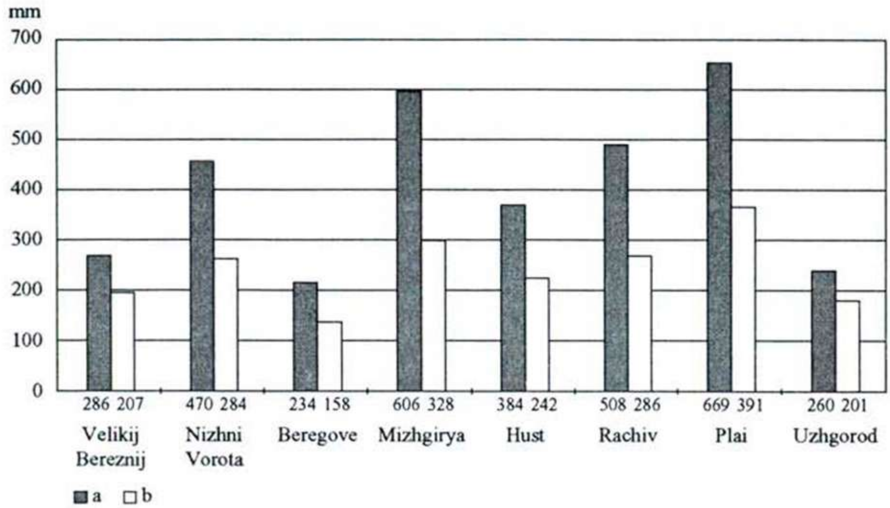



**Fig. 3. The precipitation in August–October 1998 on meteorological stations of Transcarpathian region (here and on the fig. 3, 4 – according the date State hydrometeorological station). Symbols indicate: *a* – factual precipitation, *b* – average precipitation**

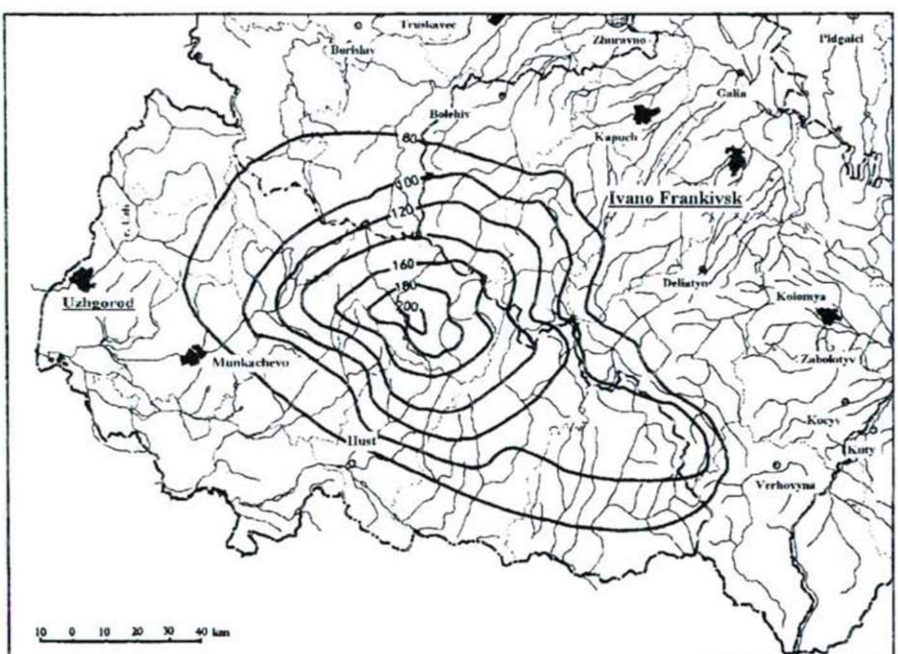



**Fig. 4. The map of isolines of precipitation in the Carpathians in 3–5 November 1998 (scale 1:1000000)**

**Table. Characteristics of water levels during the flood of 5-8 November 1998 in the Transcarpathians.**

| River | Meteo-post | Zero of post, alt. asl | Historical maximum | | Data on the flood in 5-8 November, 1998 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | water level, cm | date | H (during observa-tion) average annual, cm | H lowest water level in the river, average, cm | H max of the flood, cm | date / duration of observa-tion, min. | + H* (during observa tion), annual, cm | - H* (during observa-tion) of lowest level in 1998, cm |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Tisa | Rakhiv | 429,73 | 499 | 08.06.69 | 248 | 158 | 500 | 05.11/00 | 252 | 90 |
| | V.Bych-kiv | 294,78 | 598 | 13.05.70 | 208 | 58 | 552 | 05.11/04 | 344 | 150 |
| | Tyachiv | 208,97 | 674 | 30.12.47 | 199 | -5 | 726 | 05.11/10 | 527 | 204 |
| | Khust | 162,91 | 426 | 13.05.70 | 180 | -1 | 428 | 05.11/16 | 248 | 181 |
| | Vylok | 115,15 | 696 | 14.05.70 | 50 | -157 | 660 | 06.11/03 | 610 | 207 |
| | Chop | 92,35 | 1322 | 18.05.70 | 576 | 398 | 1328 | 08.11/18 | 752 | 178 |
| Chorna Tisa | Yasynya | 646,50 | 464 | 23.02.64 | 164 | 134 | 340 | 05.11/00 | 176 | 30 |
| Teres-va | Ust-Chorna | 523,86 | 301 | 14.12.57 | 96 | 47 | 363 | 05.11/00 | 267 | 49 |
| | Neres-nytsia | 298,38 | 349 | 01.04.62 | 10 | -86 | 305 | 05.11/00 | 295 | 96 |
| Mok-rianka | Ruska-Mokra | 549,04 | 255 | 14.12.57 | 80 | 40 | 312 | 05.11/00 | 232 | 40 |
| Tereb-lya | Kolocha-va | 531,17 | 270 | 29.10.92 | 112 | 67 | 360 | 05.11/03 | 248 | 45 |
| Rika | Mizhhir-ya | 434,22 | 478 | 14.12.57 | 113 | 69 | 378 | 05.11/04 | 265 | 44 |
| | Khust | 156,41 | 685 | 30.12.47 | 339 | 234 | 620 | 05.11/06 | 281 | 105 |
| Bor-zhava | Dovhe | 168,35 | 514 | 14.12.57 | 189 | 134 | 536 | 05.11/00 | 347 | 55 |
| | Shalanky | 114,32 | 822 | 26.07.80 | 249 | 117 | 890 | 06.11/00 | 641 | 132 |
| Latory-tsia | Pidpolo-zzya | 356,54 | 388 | 14.12.57 | 109 | 64 | 320 | 05.11/00 | 211 | 45 |
| | Svalyava | 190,00 | 416 | 01.03.67 | 120 | 96 | 304 | 05.11/04 | 184 | 24 |
| | Muka-cheve | 115,60 | 650 | 23.07.80 | 274 | 217 | 687 | 05.11/06 | 413 | 57 |
| | Chop | 96,58 | 744 | 26.07.80 | 453 | 252 | 746 | 07.11/00 | 293 | 201 |
| Stara | Znyatse-ve | 104,92 | 499 | 23.07.80 | 321 | 85 | 494 | 05.11/16 | 173 | 236 |
| Uzh | Zhorna-va | 328,29 | 296 | 14.12.57 | 53 | 14 | 246 | 05.11/02 | 193 | 39 |
| | Vel. Bereznyi | 196,26 | 527 | 14.12.57 | 228 | 196 | 433 | 05.11/01 | 205 | 32 |
| | Zariche-ve | 154,56 | 446 | 29.01.79 | 161 | 84 | 442 | 05.11/06 | 281 | 77 |
| | Uzhgo-rod | 112,38 | 350 | 17.1192 | -70 | -152 | 295 | 05.11/10 | 365 | 82 |
| Turya | Simer | 151,23 | 332 | 23.07.80 | 66 | 24 | 320 | 05.11/04 | 254 | 42 |

Designated *: + H = estimation (6) – (7); - H = estimation (8) – (6)

Heavy showers caused sudden rise of water levels in the Tisa near Tyachiv and Vylok and in the Latorytsia below Mukachiv. They were 4.1-6.1 m. At the 10 water-measuring stations the highest water level reached or exceeded a historical maximum. The data from hydro-meteorological stations are shown in the table.

It is well known from the special forestry references that forest ecosystems can, to a certain extent, hold the precipitation and regulate the surface flow of water. For the ripe forests of the Carpathians the daily precipitation is up to 175 mm [2]. At the beginning of November 1998 these indices were much higher, the soil was overmoistured, and all of these resulted in disastrous floods. Over-cutting of the mountain forests that had taken place in the past had intensified the activity of floods and other natural disasters.

The problem of floods has many aspects, therefore the system of measures for their prevention is differentiated and diverse. Water basin of a mountain river with characteristic net of water arteries should be considered as half-open eco-hydrological system. Depending on the structure of landscape where the basin is formed, on the character of hydro-net and hydrological conditions, it is possible to define four functionally connected zones in this system (Fig.5).

There is a large mountain zone accumulating water resources in the upper part in the river basin (zone "A"). It includes a wide net of streams with swift water flow, that is why there is no flood danger, but the danger of mud flow exists. It is adjacent to the piedmont transit zone (zone "B") covering foothills and mountain landscapes with possibility of bank erosion. The most dangerous as to the water chaos is the plain zone of potential decumulation of water resources (zone "C", or flood zone). It covers wide terraces and adjoining plain landscapes, dangerous to the flood of water masses. Farther this zone turns into a usual plain transit river-bed zone (zone "D"). Each of these zones demands differentiated anti-flood measures depending on their ecological and hydrological specific features.

As it was stated, floods are conditioned by both natural hydrological and anthropogenic factors. They may be different depending on the forms and scale of anthropogenic influence on the habitat.

Considering the ecological condition of mountain river basins, the character of landscapes and the structure of water net, we chose six subsystems of anti-flood measures: hydro-technical, forestry, nature conserving, agricultural, organizational and ecology-educational.

**The subsystem of hydrotechnical measures.** These measures are of paramount importance for normalization of hydrological regime of mountain rivers and are to be taken in all zones of water basins. In upper waters of rivers, dangerous as to the floods for the lower basin parts (zone "A"), it is necessary to build anti-flood reservoirs. A net of special reservoirs for rafting timber (dams, "clausura") was built at the end of XIXth and the beginning of XXth century within the basins of the Bila Tisa (village Luhy), the Chorna Tisa (v. Lazeshchyna, 3 dams; v.Chorna Tisa, site Apshynets; v.Dovzhana, river Dovzhana), in upper waters of the Tereblya (the Chorna Rika, rivers Pessya, Lubelyanka, Chernyanka). In the Ivano-Frankivsk region some reservoirs were on the river Cheremosh. Mountain water reservoirs also performed an important anti-flood function. After the times of floating of the timber had ceased, they fell into decay. But we should say that new-built mountain reservoirs could have also recreational - and the larger of them – hydro-energetic significance.

In the "B" zone, especially on the sharp turns of rivers, concrete fortifications should be built, and stone dams on the turns of small rivers.

In the "B" zone the most reliable measure against flooding is the construction of powerful dikes. On the right bank of the Tisa near Tyachiv, Vylok and other populated areas such dikes have been functioning for 80-90 years quite successfully.

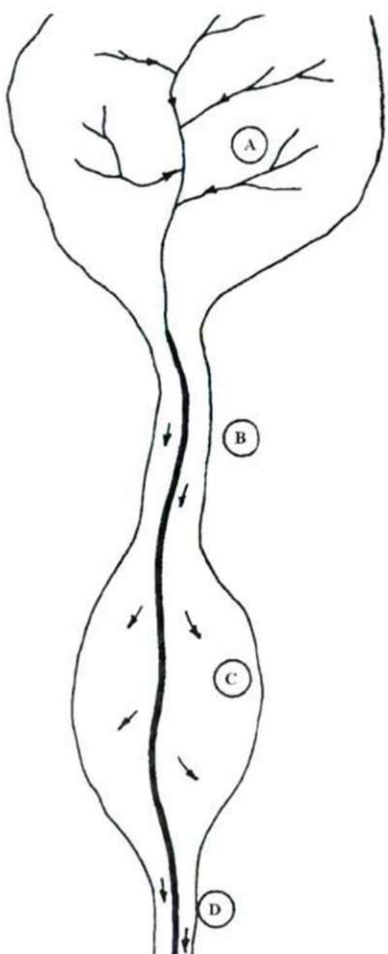



**Fig.5. The water basin as an eco-hydrological system.**

The main cause of bank erosion is the rapid water current. To slow it down it is necessary to create a system of water trestles in certain places. In these places waters become rich in oxygen, useful for fish-breeding, especially for trout breeding.

A chaotic extraction of gravel, sand and river stones harms the beds of a river, deepening them and creating the bank erosion. Such exploitation ought to be controlled and permitted only in proper places.

In order to estimate the existing ecological condition of large basins of water arteries and to forecast their functioning, it is recommended to increase the net of water-measuring stations and on their basis to organize a system of hydrological monitoring.

**The subsystem of forestry measures.** The efficiency of hydrotechnical measures in humid regions can be secured only in parallel with forestry ones. The research carried out in the Carpathians showed that the forest cover, in comparison to the non-forest one, decreases the river flow two times and the destructive maximum flow four times.

The most favourable hydrological regime in river water basins is where the forests over 40 years of age cover 65-75% area [2]. Such forest coverage should be provided in zones "A" and "B". The system of forest management in these zones is to be based on the principle of forest stability (*Dauerwald*), substantiated for the Austrian Alps the in XIXth century. The stability of forest and forest environment ensures the stability of water protective function performed by forest ecosystems. Therefore clear-cutting areas should be limited as much as possible in zones "A" and "B".

As it was noted, water basins of mountain rivers should be considered as a half-open hydrological system. To ensure the ecological balance in such systems, the forestry should be managed by the method of water basins, which is grounded for the Carpathians by O.V.Chubaty [14], V.S.Oliynyk with co-authors [6] and V.I.Parpan [7]. However, for use of this method it is necessary to consider the specific ecological features of each basin: climate (the quantity of precipitation), orography and hydrology (divided relief, hydronet character), phytocoenotic (afforestation percentage, forest age structure). Only after such integral evaluation of ecological situation it is possible to determine the volume and methods for exploiting mountain forests in the basins of corresponding rivers.

During a long pastoral period in the high mountain range of the Carpathians, the upper border of forests which hold melted waters from alpine meadows was essentially lowered. The water-protective function of these subalpine forests is several times higher than that of phytocoenoses located lower. The renewal of ecologically grounded upper forest border on high-mountain meadows of Yavirnyk, Rivna, Borzhava, Apetska, Krasna, Svydovets, Kvasivsky Menchul will improve the hydrological regime of the rivers rising there.

In Transcarpathians the forest area belonging to the agricultural economic complex makes now 136,800 ha. These formerly collective and state-farm forests situated near the mountain river beds are of importance for water protection. Unfortunately their ecological condition is unsatisfactory. It would be reasonable to pass them to the State Forest Fund to ensure forest naturalization and improvement of water-protective functions.

Now, in hard economic situation the cutting without permission increased, thus reducing the protective role of forests. In 1998 there were 3,500 $m^3$ of such cuttings in the forests of State Forest Fund and 30,100 $m^3$ in the forests of agricultural-economic complex. It is necessary to keep stronger the regime of mountain forests protection and provide local people with gas.

For mountain villages situated in potentially dangerous localities as to the structural and layer shifts it is necessary to create plans of their ecological safety (the safety of existing and planned houses, bridges, railways and highways, electric transmission lines, gas and oil pipes). Such plans must be based on special geological and landscape-ecological research.

**The subsystem of nature-protecting measures** has to be aimed to the improving of water- and soil-protective function of forest ecosystems and other types of vegetation. For this purpose it is proposed to create a net of water-protective partial reserves with special regime of forestry and agriculture in zone "A". Such plots are not withdrawals from the land fund of land users, but the latter have to use natural resources in such a way as not to violate the protective functions of ecosystems.

In flood-dangerous zones it is essentially to widen the stripes of riverside water-protective forests or in case of their absence to create them by means of cultures.

**The subsystem of agricultural measures.** A large area in mountain river basins is covered with agricultural lots which appeared in places of cut down forests. In zone "A" the main anti-flood measures should be directed to the improvement of water- and soil-protective functions of post-forest mountain meadows and pastures. Therefore eroded pastures must be afforested and turfed. The cutting down of bushes on steep slopes for increasing arable land must be forbidden. Measures must be taken against ravine (channel) and plain erosion on mountain slopes. It is desirable to reconstitute the traditional "terrace crop-growing" used before in mountain regions. It is inexpedient to use 50 m riverside zone for tilled crops.

**The subsystem of organizational measures.** Now mountain streams do not have a single manager responsible for their regulation, maintaining normal hydrological regime and protection. Since they run on the lands of State Forest Fund it would be reasonable to create a structural sub-department for protection and regulation of mountain rivers and streams.

**The subsystem of ecology-educational measures.** Forestry, agriculture and water economy in the Carpathians have their own mountain characteristic feature which is not always taken into consideration by specialists and land users. Therefore proper attention must be paid to rise the level of nature-protection knowledge as to the rational use and resumption of natural resources and preservation of ecological balance in the region.

It is desirable to exchange experience with specialists from Slovakia, Hungary and Romania in the struggle against disastrous natural phenomena.

## Conclusion

The forecast of the probability of future floods in the Transcarpathians is disastrous. The region is situated on the south-western macro-slope of the Carpathians which gets more precipitation than the north-eastern one. Transcarpathians is the zone of warmer climate, hence the process of snow melting is more rapid. There are mainly oak and beech forests under which snow melts two-three times quicker, than under evergreen dark-needle forests. There are more than 60,000 ha of treeless high-mountain meadows where tremendous snow masses are accumulated. On the Volcanic Ridge andesits and trahits prevail, that are hard waterproof rocks. The hydronet in Transcarpathians is much denser than in other Carpathian regions. The Prytysianska lowland lies 200-250 m below the plain landscapes of the Dnister. The region is a seismic zone were little earthshakers often happen, what in its turn can cause the activity of slope processes and layer shifts.

According to genetic classification of mud flows, within the Transcarpathians one can distinguish the south-western dangerous region, covering the basins of right-hand tributaries of the Tisa. There is a ridge of Pienin limestones extending from Perechyn to Dilove, where dangerous carst processes are potentially possible.

During the last decades in the Carpathians, as well as in other regions of northern hemisphere, we observe global warming of the climate under the greenhouse effect. From the 90-ies of the last century the waters in river basins of Europe rise and the same is observed in the Carpathians. All of these may cause further floods and other dangerous ecological processes. Therefore Transcarpathians should be classified as an ecologically critical region which needs a special management for forestry, agriculture and water economy. It needs changes in the orientation of economy, directing it onto decreasing forest exploitation, increasing forest coverage and rising protective functions of forest and meadow ecosystems.

Due to warm climate, different balneological resources, high recreational potential and easy accessibility of picturesque mountain landscapes, the Transcarpathians should pay more attention to recreation and tourism industry.

It is necessary that the Western Scientific Centre of National Academy of Sciences of Ukraine should substantiate a complex program for research of the flood problems and other natural phenomena for the nearest future and the perspective by drawing scientific and production potential of the region.

The Ukrainian Carpathians border with four countries having mountain systems. To solve ecological, economic and nature protecting problems successfully in the transbordered regions it would be expedient to create The Carpathian Ecological Comission.

## References

Aizenberg M.M. 1962. Unusual floods in the rivers of Carpathians in 12-13, 17-18 centuries // Proc. of Ukrainian NIGRI. – Pt.34. – P.76-78 (in Russian).

Havrusevich A., Oliynyk V. 1994. The Carpathian forests as flood regulators // Ukrainian Forest. – N2. – P.26-27 (in Ukrainian).

Holubets M.A. 1978. Spruce forests of Ukrainian Carpathians. – Kiev: Naukova dumka. – 244 p. (in Russian).

Krys Z.O. 1992. Post-forest meadows of Ukrainian Carpathians: the flora, the preservation and the rational use. Doct.Hab.thesis. – Kiev. – 36 p. (in Russian).

Lutyk R.I. 1985. Disastrous floods and their consequences // Thermal and water regime of Ukrainian Carpathians. Red. L.I.Sakali. – Kiev: Hydrometeoizdat. – P.227-263 (in Russian).

Oliynyk V.S., Parpan V.I., Chubatyi O.V. 1986. The ways on improvement of clear cutting in the forests of Carpathians // Forestry. – N3. – p.19-24 (in Russian).

Parpan V.I. 1994. Structure, dynamics and economical basis of beech forests rational use in the Carpathian region. Dr.Hab.Thesis. – Dnipropetrovsk. – 42 p. (in Russian).

Stoyko S.M. 1966. The strict reserves and nature monuments of Ukrainian carpathians. – Lviv: Lv. University. – 141 p. (in Ukrainian).

Stoyko S.M. 1993. The consequences of anthropogenic transformations in Carpathian forest ecosystems and the ways on elimination of harmful ecological processes // The Ukrainian Forest. – N2. – p.11-17 (in Ukrainian).

Stoyko S.M. 1999. The catastrophic floods in Transcarpathians and ecological measures of their prevention // The problems and perspectives of the forestry education, science and practice development. Proc. of international scientific-practice conference. – Lviv. – P.119-120 (in Ukrainian).

Stoyko S.M., Milkina L.I., Solodkova T.I. et al. 1980. Nature conservation of Ukrainian Carpathians and adjacent territories. – Kiev: Nauk. dumka. – 260 p. (in Ukrainian).

Stoyko S., Shevchenko G. 1994. Roaming waters (the ecological grounding of counter-flood measures) // The green Carpathians. – N 1-2. – P.44-47 (in Ukrainian).

Chubatyi O.V. 1969. The protecting role of Carpathian forests. – Uzhgorod: Karpaty. – 134 p. (in Ukrainian).

Chybatyi O.V. 1981. The forestry in water basins // Forestry. – N1. – P.3-11 (in Russian).

Stoyko S. 1997. The causes of flood in the Ukrainian Carpathians and the system of their prevention // CERECO'97. The 2-nd International Conference on Carpathian Euroregion, Miskolc, 1997. – P.23-29 (in English).

Zeleny V. 1967. Interception and horizontal precipitations in the Beskyd Mts. // Meteorological Issues. – N6. – P.6-8 (in Slovakian).

S. M. STOYKO
Institute of Ecology of the Carpathians,
National Academy of Sciences of Ukraine,
Lviv.

# USEFULNESS OF EUKARYOTIC AND PROKARYOTIC MICROORGANISMS IN THE INVESTIGATION OF WATER QUALITY IN THE MUREŞ RIVER

*László Fodorpataki and Judit Papp*


## Abstract

The development of physiological tolerance to the chemical stress caused by pollution of the aquatic environment with cadmium ions can be detected by different fuctional and biochemical parameters of the algal cells present in the phytoplankton of different river sectors. The investigation of such parameters that indicate early symptoms of heavy metal pollution revealed that the intensity of enzymatic $H_2O_2$-degradation is a suitable tool to appreciate the tolerance developed by phytoplankters to cope with polluting agents which act as oxidative stress factors. Among the main photosynthetic pigments, only the amount of chlorophyll-b exhibits a regular correlation with the degree of water pollution caused by cadmium. The influence of this heavy metal on the net biomass production of the phytoplankton is also investigated, and the usefulness of prokaryotic decomposers in the estimation of water quality is discussed.


**Keywords:** phytoplankton, stress tolerance, water pollution, cadmium, oxidative damage

## Introduction

Planktonic microalgae are primary biomass producers in the aquatic ecosystems, while heterotrophic bacteria play an important role in decomposing the different organic substances in the water. Both of these two groups of microorganisms exhibit a pronounced metabolic plasticity and a high growth potential. Thus, they may be used to monitor the degree of water pollution with different inorganic and organic chemicals that indicate human impact and may threaten the health of the riverine populations.

The phytoplankton, consisting of microscopic algae that have little or no resistance to currents and live free-floating in open waters, occur as unicellular, colonial or filamentous forms. From a physiological and ecological point of view, the floating cyanobacteria are also included in the phytoplankton. Most of the small organisms are photosynthetic and are grazed upon by zooplankton and other aquatic creatures. Phytoplankton organisms long have been used as indicators of water quality. Some species flourish in highly eutrophic waters while others are very sensitive to different chemical wastes (Hamar 1995). Some species have been associated with noxious blooms, sometimes creating offensive tastes and odors or toxic conditions. Because of their short life cycles, plankters respond quickly to environmental changes, and hence the standing crop and the species composition indicate the quality of the water mass in which they are found. Because of their transient nature and often patchy distribution, information on plankton as indicators is interpreted best in conjunction with concurrently collected, physicochemical and other biological data (Munawar 2000).

The microflora of rivers consists of autotrophic and heterotrophic, aerobe or anaerobe microorganisms that are involved in the natural cycle of chemical elements, in the production, degradation, transformation and mineralization of natural organic compounds, as well as in the bioconversion of xenobiotics originating from different human activities. Many polluting agents that are released in different sectors of rivers seriously endanger the dynamic equilibrium of the aquatic communities. The partial self-cleaning process of water becomes possible only upon the close interaction between autotrophic and heterotrophic microorganisms, that produce and decompose new organic compounds and sustain all of the life forms that are characteristic for an aquatic ecosystem (Fodorpataki and Papp 2000).

Stress can be regarded as a functional state or as the dynamic response of the whole organism. It represents a significant deviation from the conditions optimal for life, and eliciting changes and responses at all functional levels of the organism which, although at first reversible, may also become permanent. Stress can be regarded as a directional event, induced by highly specific factors, but the response may have common steps for several different stressors. Often, the external factors does not reach the ultimate site of the stress reaction immediately or in its original intensity, because plants possess a variety of protective mechanisms to delay or even prevent disruption of the thermodynamic or chemical equilibrium between environment and cell interior. The stress response is a race between the effort to adapt and the potencially lethal processes in the protoplasm. Thus the dynamics of stress comprises a destabilizing, destructive component, as well as countermeasures promoting restabilization and resistance (Schnell 1994). Constraint, adaptation and resistance are thus interconnected parts of the whole event. Reactions that indicate a state of stress make possible the employment of sensitive plant species as bioindicators of environmental stress, or the use of living plants as biomonitors of specific habitat parameters. Both categories are widely represented among the freshwater microalgae.

The aim of this study is to reveal metabolic properties of microalgal and bacterial populations isolated from different sectors of the Mureş River, and to corelate the physiological parameters with the water quality of the river, in order to achieve a better understanding of how invisible life forms react to the challenge represented by anthropic influences on aquatic communities.

## Material and methods

Cell populations of the same algal species (*Scenedesmus opoliensis* P. Richt.) were isolated from 3 different sampling sites along the Mureş River, and cultivated under controlled conditions, in nutrient media without and with supplementation with 0.1 mM cadmium as a polluting agent. The tolerance of the algal populations to this stress condition was investigated by determining the peroxide-scavenging enzyme activities, the chlorophyll *a* and *b* content and the dry biomass production after 10 days of cultivation. The photosynthetic pigment content was determined spectrophotometrically after extraction with methanol and acetone, performed in dim light at 4°C. The activity of $H_2O_2$ decomposing enzymes was assayed titrimetrically, by measuring the remaining hydrogen peroxide after 1 hour of incubation in the presence of a known amount of $H_2O_2$. Biomass production was evaluated by dry weight measurement (Fodorpataki *et al.* 2001).

The bacteriological investigations of the water samples include the determination of the total number of heterotrophic bacteria (on nutrient agar, 48h incubation at 37°C), as well as the abundance of some indicator species, such as the coliforms (in Durham tubes with lauryl-sulphate broth) and the streptococci (in inoculation tubes with bromocresol-purple-azide medium). For these determinations water dilutions were prepared from $10^{-1}$ to $10^{-7}$, and these were inoculated in selective nutrient media that allow the growth of specific bacterial groups. The most probable number of the different bacteria was established using the De Man table, based on the number of positive tubes (Fodorpataki and Papp 2000, Greenberg *et al.* 1995, Rompré et al. 2002).

The sampling sites were:

1. Gălăoaia, with unpolluted water on the upper section of the river
2. Gura Arieş, situated downstream to the confluence of the heavily polluted Arieş River with the Mureş
3. Pecica, with partially self-purified water, on the lowest section of the Mureş River.

## Results and discussion

Today, as a result of human activities, plants are exposed to far greater amounts of harmful substances than before. These are chiefly xenobiotics to which plants could not become accustomed yet. Land-use practices around the world have often resulted in degraded ecosystems that will not return rapidly to their original state. Commonly, the disturbed habitat has many stressors that impact plant functions, and restoration can be assisted by judicious incorporation of species or ecotypes that can tolerate the stresses of these damaged ecosystems (Jackson and Black 1993, Kullberg 1995). In this context, stress tolerance of microalgae, as the main primary biomass producers of the aquatic ecosystems, plays a crucial role in the remediation of anthropically polluted water ponds (Fodorpataki and Trifu 1995).

Stress is reflective of the amount of environmental pressure for change that is placed on different biological processes of an organism, inducing an alarm response. These responses may be defensive or adaptive, and stress occurs when the unfavorable environmental factors induce enough functional change to result in reduced growth, reduced yield, physiological acclimation, species adaptation, or a combination of these. Because of their short life cycle and high contact area of all the cells with the environment, as well as due to their pronounced metabolic plasticity, microalgae are especially suitable organisms to study the influence of environmental changes on aquatic organisms. Responses to stressors can be divided into two possibilities. In the case of tolerance plants have mechanisms that maintain high metabolic activity under mild stress and reduced activity under severe stress. In contrast, mechanisms of avoidance involve a reduction of metabolic processes, resulting in a dormant state, upon exposure to long-term extreme stress (Pugnaire and Valladares 1999).

Many pollutants induce oxidative stress conditions in the living organisms (Ray and Gaur 2001). Algal cells are able to protect themselves against harmful active oxygen compounds, e.g. by decomposing $H_2O_2$. In the presence of $Cd^{2+}$, the $H_2O_2$-scavenging enzyme activity is much higher in the algae selected from polluted water samples (Fig. 1). This indicates that phytoplankters are able to acclimate to variations of the chemical composition of the aquatic environment, and in a relatively short period of time those individuals become dominant which have the ability to develop a more efficient defensive mechanism with the contribution of their inducible enzyme systems. In other words, the microalgal populations originating from polluted sectors of the river are better prepared to cope with the oxidative stress induced by the presence of cadmium ions dissolved in the water. This may be a suitable explanation for the fact that the algal populations isolated from Gura Aries (the sampling site with the most heavily polluted water) exhibit a much higher activity of the peoxide-scavenging enzymes, even in the absence of the chemical stress factor represented by cadmium.

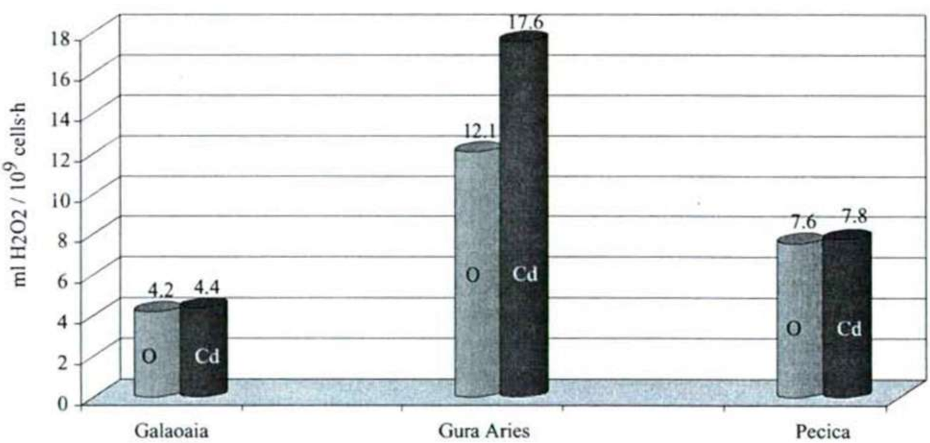



**Fig. 1. Activity of hydrogen peroxide-scavenging enzymes in cells of *Scenedesmus opoliensis*, originating in 3 different sectors of the Mureş River, cultivated in unpolluted (0) and Cd-polluted (Cd) media**

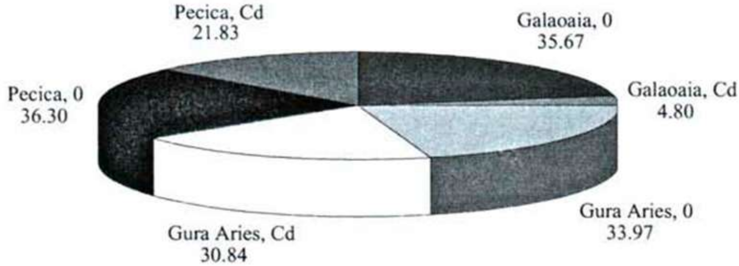



**Fig. 2. Changes in the chlorophyll-b content (microgram per gram d.w.) of cells of *Scenedesmus opoliensis* originating in 3 different sectors of the Mureş River, cultivated in unpolluted (O) and cadmium-polluted (Cd) media**

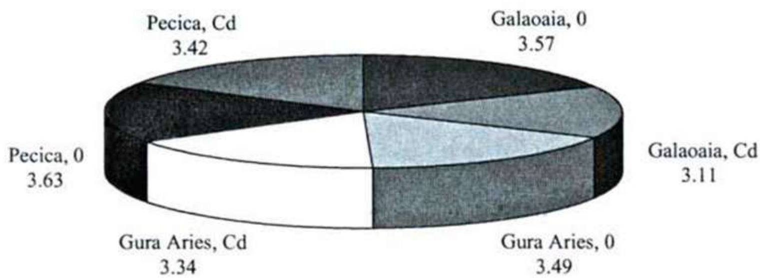



**Fig. 3. Changes in the P700 chlorophyll-a content (microgram per gram d.w.) of cells of *Scenedesmus opoliensis* originating in 3 different sectors of the Mureş River, cultivated in unpolluted (O) and cadmium-polluted (Cd) media**

The equilibrium between biosynthesis and degradation of chlorophyll-*b* is also influenced by polluting agents. The algal populations which had become tolerant, are able to maintain this equilibrium under stress conditions, while the other populations show an obvious decline in the amount of chlorophyll-*b* in the presence of Cd (Fig.2). Even under a constant illumination, the size of the light-harvesting pigment-protein complexes varies on a large scale if different stressors are present in the algal cells. Chlorophyll-*b*, which in greea algae is the main accessory photosynthetic pigment, is present mainly in the very dynamic peripherical regions of the light-harvesting complexes.

Pollutants the inhibit any segment of the biosynthetic pathway of this pigment, or enhance its degradation, will reduce the overall amount of chlorophyll-*b*, thus causing a decreased efficiency of energy absorption by the algal cells, which finally may result in the decline of biomass production. This suggests that monitoring the quantity of chlorophyll-*b* under specific light conditions may represent a useful tool for detecting the disturbance of energy input into the aquatic communities, caused by polluting agents (such as cadmium). In contrast, the amount of one of the most important types of chlorophyll-*a* (known as the P700 pigment) is highly stable under different conditions, being not suitable for the detection of unfavorable water quality (Fig. 3).

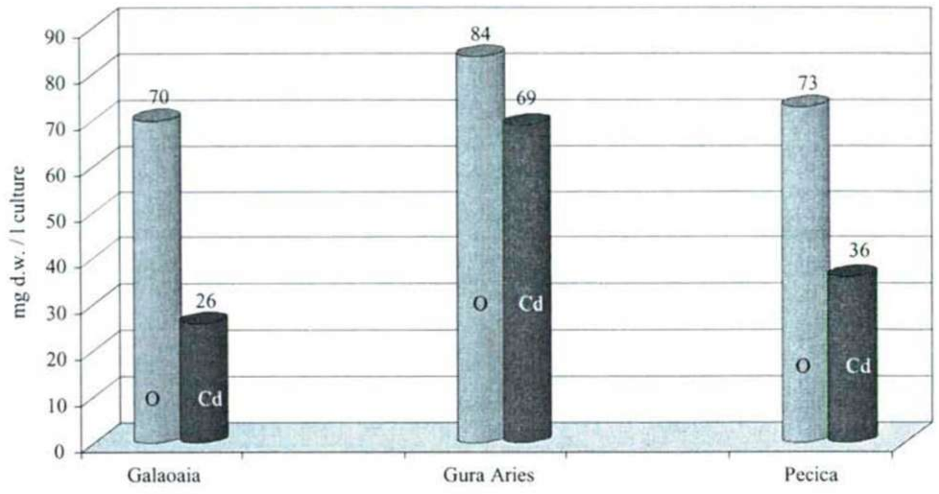



**Fig. 4. Dry biomass production after 10 days of cultivation of *Scenedesmus opoliensis* populations, originating in 3 different sectors of the Mureş River, cultivated in unpolluted (0) and Cd-polluted (Cd) media**

The dry biomass production is mostly affected by heavy metal contamination in the algal populations isolated from the unpolluted upper sector of the Mureş River (Fig. 4). This suggests that acclimation to harmful conditions is a prerequisite of the survival of microalgae in polluted environments. Small variations of the dry biomass can be registered even in the absence of the polluting agent, but the presence of dissolved cadmium induces a much more pronounced decline in dry weight of the unacclimated populations than in the case of the representatives of the same algal species isolated from a heavily polluted sector of the Mureş River.

These results reflect that by examining the different populations of the same algal species, their physiological sensitivity or tolerance to polluting agents directly indicates the quality of the aquatic environment.

The above presented invastigations can be completed with the study of different physiological categories of heterotrophyc microorganisms that are strongly interconnected with the planktonic primary producers, and in the same time provide us with useful information about hygienical parameters of the water. The chemical pollutants also affect the growth and diversity of these heterotrophic bacteria that decompose the body of dead organisms and many xenobiotics, as well (Gauthier and Archibald 2001). In this regard one suggestive example will be given bellow, while the influence of water pollution on other bacterial groups will be presented separately.

Accumulation of soluble heavy metals in the water leads to a decreased number of bacteria, while the number of coliforms and faecal streptococci is the highest in the lower sector of the river, which is loaded with organic substances from household wastewaters. This reflects that the chemical nature of the pollutants is the main determinant of the development of different prokaryotic microorganisms alon the different sectors of the river (Tab. 1).

Table 1. The number of different types of bacteria at 3 sampling sites along the Mureş River (in 1 ml of water)

| Sampling sites | Total number of bacteria | Coliforms | Faecal streptococci |
|---|---|---|---|
| Gălăoaia Sept. 1999 | 632 | 3 | 0.1 |
| Gălăoaia Dec. 1999 | 620 | 3 | 0.1 |
| Gălăoaia May 2000 | 584 | 3 | 0.1 |
| Gălăoaia Aug. 2000 | 654 | 3 | 0.1 |
| Gura Arieş Sept. 1999 | 300 | 27 | 0.8 |
| Gura Arieş Dec. 1999 | 204 | 54 | 9.2 |
| Gura Arieş May 2000 | 600 | 28 | 7.0 |
| Gura Arieş Aug. 2000 | 324 | 27 | 7.0 |
| Pecica Sept. 1999 | 6000 | 110 | 0.7 |
| Pecica Dec. 1999 | 660 | 348 | 6.1 |
| Pecica May 2000 | 4820 | 140 | 5.1 |
| Pecica August 2000 | 5800 | 173 | 5.1 |

The values of total number of bacteria and the number of coliforms and streptococci indicate clean, unpolluted water in the upper section of the Mureş river (Gălăoaia) in all sampling periods. In this region the river flows far from the human settlements and the polluting sources, and the life of the aquatic communities is not perturbed. The water brought by the Arieş River pollutes the water of the Mureş, the unfavourable effect being reflected by the presence of coliforms and especially of streptococci in high number at the confluence site of the Mureş with the the Arieş in every sampling period, excepting September, when the values were lower. The total number of bacteria and the number of indicators increase significantly in the lower region of the river, indicating strongly polluted water. The household wastewater and the by-products coming from agriculture and animal husbandry that are released in the river determine the contamination of the water with faecal materials and increase the amount of the indicator microorganisms. The highest values were registered in the last sampling site along the Mureş (Pecica). The presence of pathogens in a number above of the admissible values makes the water unsuitable even for bathing or for irrigation of crops that serve as food or fodder.

## Conclusions

1. Functional parameters of algal cells, such as $H_2O_2$-scavenging enzyme activity, chlorophyll-*b* and net bioproductive potential, are good indicators of tolerance or sensitivity to water pollution with heavy metals.
2. By examining the physiological tolerance of different ecotypes of the same *Scenedesmus opoliensis* species, collected from the different sampling sites along the

Mureş, and cultivated under controlled experimental conditions in culture media enriched with cadmium-chloride, very elocvent conclusions can be drawn concerning the pollution of the aquatic environment to which the examined ecotypes belong. Under controlled experimental conditions, the algal populations originating in polluted water exhibit a higher capacity to cope with stressful conditions.

3. The most sensitive populations to heavy metal pollution are those inhabiting the upper and the lowermost sections of the river (Gălăoaia and Pecica).

4. The algae that are mostly tolerant to high concentrations of heavy metals were identified at Gura Arieş, where the Arieş river brings highly polluted waters.

5. The amount of coliforms and faecal streptococci from the total number of bacteria is an indicator of the degree of water pollution with organic compounds of anthropic origin.

6. The water brought by the tributary streams (Arieş and Târnava), loaded with organic materials, perturbs the natural microbial communities, increasing the number of faecal indicators, especially of streptococci.

**Acknowledgement**

The study was supported by the CNCSIS Grant T 138 cofinanced by the World Bank.

**References**

Fodorpataki L., Márton A. L., Csorba T. L. (2001): Stress-physiological investigation of algal cell cultures in polluted media, Contrib. Bot. 36: 101-108.

Fodorpataki L., Papp J. (2000): Studies concerning the physiology of microalgal communities isolated from natural habitats, Contrib. Bot. 35: 121-130.

Fodorpataki, L., Trifu, M. (1995): Influence of heavy metals on photosynthetic parameters under different light conditions in cultures of *Scenedesmus acutus* M. In: Mathis, P. (ed.), Photosynthesis: from Light to Biosphere, Kluwer Acad. Publ., Amsterdam: 529-532. 5.

Gauthier, F., Archibald, F. (2001): The ecology of fecal indicator bacteria commonly found in pulp and paper mill water systems, Wat. Res. 35(9): 2207-2218.

Greenberg, A.E., Rhodes-Trussell, R., Clesceri, L.S. (1985): Standard Methods for the Examination of Water and Wastewater, Port City Press, Baltimore.

Hamar J. (1995): Algological studies of the Maros (Mureş) River. In: Hamar J., Sárkány-Kiss A. (eds.): The Maros/Mureş River Valley, Tisza Klub, Szolnok-Szeged-Tg. Mureş: 149-163.

Jackson, M. B., Black, C. R. (1993): Interacting Stresses on Plants in a Changing Climate, Springer Verlag, Berlin: 267-286.

Kullberg, R.G. (1995): Decreased diversity caused by differential inhibition among artificial phytoplankton communities in an undisturbed environment, Eur. J. Phycol. 30: 267-272.

Munawar M. (2000): Bioindicators of environmental health, Backhuys Publ., Leiden

Pugnaire, F. I., Valladares, F. (1999): Handbook of Functional Plant Ecology, Marcel Dekker Inc., New York: 171-194.

Ray L.C., Gaur J.P. (2001): Algal adaptation to environmental stresses, Springer Verlag 8.

Rompré, A., Servais, P., Baudart, J., de-Roubin, M. R., Laurent, P. (2002): Detection and enumeration of coliforms in drinking water: current methods and emerging approaches, J. Microbiol. Methods 49: 31-54.

Schnell, R. (1994): Les Stratégies Végétales, Masson, Paris: 111-117.

LÁSZLÓ FODORPATAKI and JUDIT PAPP
Babes-Bolyai University
Dept. Plant Biology
RO-3400 Cluj-Napoca
1 Kogalniceanu st.

# PHYTODIVERSITY OF TRANSYLVANIAN HYDROGRAPHIC BASINS

*Constantin Drăgulescu*

**Abstract**

Based on field researches accomplished between 1991 and 1999 but also on all references, the present paper establishes a synthesis on the aquatic and paludal flora from the main rivers' basins from whole Transylvania. The status of species encountered in the red lists and the main natural protected areas are also concerned. Between 23% and 32,8% of the flora is considered endangered in the specified area.

**Keywords:** Flora, vegetation, wetlands, Red List.

## Introduction

This paper offers succint information about the aquatic and paludal flora of the Transylvanian hydrographic basins (Someş, Criş, Mureş and Olt), about the plant species included in the Romanian red list, the main wetlands where they grow and the protected areas of these basins.

The data are the result of field research performed, in the 1991-1999 period, and of bibliography and herbariums consultation. These were published extensively in 1995 (Mureş), 1997 (Criş), 1999 (Someş, Olt). In the mentioned papers, only the species which grow near the ***main rivers course*** (including the sectors belonging to Hungary) were enumerated, but in this paper the numbers render the ***whole basins*** phytodiversity (excluding the sectors belonging to Hungary). The hybrids are not presented in the paper. Concerning the red list of Romanian flora, only extinct (Ex), endangered (E), vulnerable (V) and rare (R) plants were selected (excluding species with an uncertain status of integration in one or another category).

## The Someş Basin

***Phytodiversity and red list.*** In the Someş Basin there were identified 2050 species (cormophytes), of which 455 are aquatic and paludal species. The flora is rich in species as a result of the river's course length, which runs through several different forms of relief with different geological substrates and varied soils, as well as distinct climates. One important factor is also that the Someş River has two components: the Someşul Mic with the springs in the Western Carpathians, and the Someşul Mare that springs from the Eastern Carpathians. 86 plants of these 455 aquatic and paludal species are on the red list. We illustrate this with the following examples: *Achillea impatiens, Achillea ptarmica, Andromeda polifolia, Angelica archangelica, Aster bellidiastrum, Blackstonia perfoliata, Calla palustris, Carex atrofusca, Carex bicolor, Carex loliacea, Cladium mariscus, Cnidium dubium, Cochlearia borzaeana, Comarum palustre, Drosera intermedia, Elatine alsinastrum, Eleocharis quinquefolia, Elisma natans, Empetrum nigrum, Euphorbia carpatica, Glaux maritima, Hippuris vulgaris, Isoetes lacustris, Ledum palustre, Liparis loeselii, Ludwigia palustris, Montia fontana, Najas minor, Narcissus angustifolius, Pedicularis limnogena, Pedicularis sceptrum-carolinum, Potamogeton coloratus, Ranunculus ophioglossifolius, Ranunculus polyphyllus, Rhynchospora alba, Ruppia rostellata, Salix aurita, Salix bicolor, Salix rosmarinifolia, Scheuchzeria palustris, Sparganium minimum, Stellaria palustris, Swertia perennis, Tofieldia calyculata, Trapa natans, Trichophorum alpinum, Utricularia bremii, Valeriana simplicifolia, Veronica scardica, Viola epipsila, Viola uliginosa, Zannichellia palustris.*

***Wetlands***: in the *Someşul Cald Basin*: Barsa, Calciş, Padiş, Sâvla, Cuciulata, Onceasa, Piatra Grăitoare, Izbuc, Ic, Călineasa, Pietrele Onachii, Între Şimone, Doda, Gura Firii, Tău Negru, Pârâul Cărbunilor, Şilica, Râşca, Ciurtuci; in the *Someşul Rece Basin*: Măguri, Dameş, Muntişoru, Cotul Someşului, Sub Zăpode, Ciunget, Balomireasa, Tăul Zânelor, Mocirle, Tăul Căpăţânii, Blăjoaia; in the *Someşul Mic Basin*: Sălicea, Valea Morii-Feleacu; in *Someşul Mare Basin*: Tinovul Câmpeilor-Ilva Mare, Zagra, Nimigea de Jos, Budacul de Jos, Şintireag, Mogoşeni; in the *United Someş Basin*: Hida, Mireşu Mare, Satulung, Homoroade, Ardusat; in *Lăpuş Basin*: Tău Negru, Recea-Lăpuşel, Groşi; in the *Crasna Basin*: Ecedea (disappeared).

***Protected wet areas*:** Valea Izbucelor, Padiş, Valea Morilor, Lacul Ştiucilor, Sic, Budacul de Jos, Mogoşeni, Zagra, Baia Mare, Rodna National Park, Apuseni National Park.

## The Criş Basin

***Phytodiversity and red list***. The Transylvanian Criş Basin flora is estimated at 1850 species, 361 species being aquatic and paludal plants. The diversity is lower than that of Someş Basin, due to its smaller area and its limited localisation between the Western Carpathians and Pannonic Plain. 60 aquatic and paludal plants are included in the red list. Ex.: *Acorus calamus, Alisma gramineum, Angelica archangelica, Carex lasiocarpa, Elatine alsinastrum, Elatine hexandra, Elatine hungarica, Elatine triandra, Fritillaria meleagris, Gladiolus palustris, Iris sibirica, Lindernia procumbens, Ludwigia palustris, Marilea quadrifolia, Montia montana, Najas minor, Narcissus angustifolius, Nuphar lutea, Nymphaea lotus ssp. thermalis, Pedicularis limnogena, Potamogeton trichoides, Ranunculus circinatus, Rhynchospora alba,* *Sagittaria subulata, Salix aurita, Scheuchzeria palustris, Scirpus radicans, Sparganium minimum Stellaria palustris, Stratiotes aloides, Succisella inflexa, Swertia perennis, Trapa natans, Trollius europaeus, Utricularia australis, Vallisneria spiralis, Veronica catenata, Wolffia arrhiza.*

***Wetlands***: in the *Crişul Repede Basin*: Călăţele, Dâmbul Negru, Tăul Runcului, Negruşul Finciului, Murgaş, Stâna de Vale, Remeţi, Morlaca-Huedin, Peţea-Oradea; in the *Crişul Negru Basin*: Cefa, Rădvani, Martihaz, Mădăraş, Salonta, Avram Iancu, Tulca; in the *Crişul Alb Basin*: Ineu, Bocsig, Beliu, Gurahonţ, Sebiş, Pâncota, Chişinău-Criş, Vărşand.

***Protected wet areas***: Bălţile Gurahonţ, Peţea-Oradea, Apuseni National Park.

## The Mureş Basin

***Phytodiversity and red list.*** Due to the fact that the Mureş Basin is the largest hydrographic basin of Transylvania, and the Mureş River has tributaries in all Eastern, Southern and Western Carpathians, the phytodiversity is high. This basin's flora is estimated at 2120 species of which 458 are aquatic and paludal plants, 86 of them being included in the red list. Ex.: *Achillea impatiens, Andromeda polifolia, Angelica archangelica, Angelica palustris, Apium nodifolium, Apium repens, Barbaraea lepuznica, Betula humilis, Calla palustris, Carex brunescens, Carex chordorrhiza, Carex heleonastes, Carex limosa, Cnidium dubium, Elatine alsinastrum, Epilobium alsinifolium, Epilobium nutans, Evonymus nana, Fritillaria meleagris, Gladiolus palustris, Glaux maritima, Groenlandia densa, Hammarbia paludosa, Hottonia palustris, Lindernia procumbens, Lysimachia thyrsiflora, Marselia quadrifolia, Narcissus angustifolius, Orchis laxiflora, Osmunda regalis, Pedicularis sceptrum-carolinum, Peucedanum rochelianum, Potamogeton alpinus, Potamogeton compressus, Ranunculus polyphyllus, Rhyncospora alba, Salix rosmarinifolia, Saxifraga hirculus, Scirpus radicans, Schoenus ferrugineus, Senecio paluster Spiraea salicifolia, Stellaris longifolia, Succisella inflexa, Taraxacum fontanum, Trichophorum alpinum, Utricularia australis, Utricularia minor, Viola epipsila.*

***Wetlands***: Voşlobeni, Joseni, Borzont, Remetea, Târgu Mureş, Ideciu, Ocna Mureş, Pecica-Bezdin, Nădlag; in the *Târnava Mare Basin*: Vârşag, Dealu, Şaeş; in the *Târnava Mică Basin*: Praid, Pasul Corundului; in *Arieş Basin*: Ierişoara, Dumitreasa, Izvorul Şoimului, La Potcoavă, Muntele Mare, Mluha-Ponor, Valea Cepilor, Valea Rătăcită-Săgacea; in the *Sebeş Basin*: Tărtărău, Sălane, Oaşa, Prigoana; in the *Strei Basin*: Pui, Nucşoara

***Protected wet areas***: Voşlobeni, Pădurea Mociar, Pui, Nucşoara, Bezdin, Retezat National Park.

## The Olt Basin

***Phytodiversity and red list.*** Although we are referring only to the upper and middle Olt River Basin, due to the fact that only these sectors are located in Transylvania, the flora is the richest (2130 species) as compared with all the hydrographic basins of Transylvania. This is because the Olt River has tens of tributaries from Eastern and Southern Carpathians and, in the same time is the southest basin of Transylvania. Of all these cormophythes 445 species are aquatic and paludal plants and 77 of them are included in the red list. From this list I am quoting: *Achillea ptarmica, Acorellus pannonicus, Acorus calamus, Angelica palustris, Apium repens, Armeria barcensis, Betula humilis, Betula nana, Calla palustris, Calamagrostis neglecta, Carex contigua, Cladium mariscus, Cnidium dubium, Comarum palustre, Drosera anglica, Drosera intermedia, Elatine hexandra, Eleocharis uniglumis, Euonymus nana, Fritillaria meleagris, Groenlandia densa, Hippuris vulgaris, Hotonia palustris, Iris sibirica, Isolepis setacea, Isolepis supina, Juncus bulbosus, Ligularia sibirica, Lysimachia thyrsiflora, Menyanthes trifoliata, Narcissus angustifolius, Nuphar luteum, Nymphaea alba, Pedicularis sceprum-carolinum, Peucedanum rochelianum, Plantago maxima, Polemonium coeruleum, Primula farinosa, Ranunculus rionii, Rhynchospora alba, Salix aurita, Salix rosmarinifolia, Saxifraga hirculus, Saxifraga mutata, Schoenus ferrugineus, Scheuchzeria palustris, Scirpus radicans, Serratula wolffii, Sesleria uliginosa, Sparganium minimum, Spiraea salicifolia, Stellaria longifolia, Stratiotes aloides, Trapa natans, Trollius europaeus, Typha shuttleworthii, Utricularia bremii, Valeriana simplicifolia, Veronica catenata, Viola epipsila, Zannichellia palustris.*

***Wetlands***: Mădăraş, Racu, Între Olturi, Miercurea-Ciuc, Jigodin, Borsáros and Lucs-Sâncrăieni, Misentea, Büdös-Sântimbru, Sânsimion, Vrabia, Tuşnadul Nou, Mohoş-Tuşnad, Prejmer, Hărman, Stupini, Sânpetru, Bod, Feldioara, Sântion-Luncă, Arini, Aita Mare, Micloşoara, Apaţa, Ormeniş, Augustin, Comana de Jos, Şinca Nouă, Dumbrava Vadului, Şercăiţa, Toderiţa, Bărcul Hurezului, Râuşor, Mândra, Arpaşul de Jos, Avrig, Bradu, Sebeş-Olt, Turnu Roşu.; in the *Râul Negru Basin*: Estelnic, Mereni, Lunga-Ojdula, Bálványos-Turia, Catalina-Ghelinţa, Borşneul Mare-Zagon, Mestecăniş-Reci, Malnaş-Băi; in the *Baraolt-Vârghiş Basin*: Vârghiş, Băile Ozunca, Băile Harghita; in the *Homorod Basin*: Căpâlniţa, Vlăhiţa-Lueta, Ocland; in the *Hârtibaci Basin*: Movile, Coveş, Bârghiş; in the *Cibin Basin*: Sibiu (disappeared), Şuvară-Tălmaciu, Cristian, Mag, Frumoasa, Iujbea Cacovei,

***Protected wet areas***: Borsaros-Sâncrăieni, Tinovul Lucs, Dumbrava Harghitei-Vlăhiţa, Reci, Hărman, Stupini, Mohoş-Tuşnad, Büdös-Sântimbru, Prejmer, Dumbrava Vadului, Bâlea, Arpăşel, Şuvară-Tălmaciu, Cheile Bicazului-Hăşmaş National Park, Bucegi National Park, Piatra Craiului National Park.

## Conclusions

Observing the data included in Tab. 1, we ascertain that in the investigated hydrographic basins, as well as in all Transylvania and Romania, 16,6%-18,9% of the wet ecotops' flora is threatened, while 23,0%-32,8% of the integral flora is endangered.

This means that there are in suffering more xerophylous and mesoxerophylous species than hydro-, hygro- and hygromesophylous plants. Indeed, over 35% of the Romanian steppe and sylvosteppe species are included in the red list. Comparing the flora of Transylvanian hydrographic basins, the data guide to the conclusion that the richest phytodiversity is in the Olt Basin, followed by the Mureş, Someş and Criş basins, and this phytodiversity is the mostly threatened in the Mureş and Someş Basins. For a more exact estimation also the extent of the basins must be taken into account, because at a certain surface the number of species does not increase proportionally with the analyzed area extension.

**Tab. 1. Comparative data concerning each hydrographic basin, Transylvanian and Romanian flora**

| *Basins* | *Surfaces in Transylvania* | *Number of species* | *Species in the red list* | *Threat degree of flora* | *Hydro-, hygro- and mezohygrophyle species* | *Species in the red list* | *Threat degree of aquatic and paludal flora* |
|---|---|---|---|---|---|---|---|
| Someş | 15.015 km² | 2050 | 520 | 25,4% | 455 | 86 | 18,9% |
| Criş | 14.120 km² | 1850 | 460 | 24,9% | 361 | 60 | 16,6% |
| Mureş | 27.830 km² | 2120 | 570 | 26,9% | 458 | 86 | 18.8% |
| Olt | 13.340 km² | 2130 | 490 | 23,0% | 445 | 77 | 17,3% |
| Total | 70.405 km² | 2830 | 780 | 27,6% | 560 | 102 | 18.2% |
| Romania | 237.500 km² | 3630 | 1190 | 32,8% | 680 | 126 | 18,6% |

## References


Drăgulescu, C.,1995, The flora and vegetation of the Mureş (Maros) Valley, The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment, Tiscia monograph series, Szolnok-Szeged-Târgu Mureş, 47-111

Drăgulescu, C., Macalik Kunigunda, 1997, The aquatic and paludal flora and vegetation from the Criş/Körös Valleys. The Criş/Körös Rivers' Valleys. A study of the geography, hydrobiology and ecology of the river system and its environment, Tiscia monograph series, Szolnok-Szeged-Târgu Mureş, 47-80

Drăgulescu, C., Macalik, Kunigunda, 1999, The aquatic and paludal flora and vegetation from the River Someş (Szamos) Valleys. A study of the geography, hydrobiology and ecology of the river system and its environment, Tiscia monograph series, Szolnok-Szeged-Târgu Mureş, 77-104

Drăgulescu, C., 1999, The hydrophilous and hygrophilous flora and vegetation from the upper and middle Olt River Valley, Transylvanian Review of Systematical and Ecological Research, Sibiu, 1, The Upper and Middle Olt River Basin, "Lucian Blaga" Univ. Press, 13-30

Oltean, M. and colab., 1994, Lista rosie a plantelor superioare din România, (Red list of higher plants from Romania), Studii, sinteze şi documentaţii de ecologie, I, Acad. Rom.-Inst. Biol.,Bucuresti.

Pop,E., 1960, Mlaştinile de turbă din R.P.Română (Swamps from R.P. Română), Edit. Acad. Bucureşti

Săvulescu, Tr. (red.), Flora R. P. Română and Flora R.S. România, I-XIII, Edit. Acad. Bucuresti, 1952-1976.

Toniuc, N. and colab., 1992, Lista ariilor protejate din România (The list of protected area from Romania), Ocrot. nat. Bucureşti, 36, 1, 23-33

DRĂGULESCU C.
Lucian Blaga University, Sibiu, Romania
31 Oituz St.
2400 Sibiu, RO

# VEGETATION DESCRIPTION OF REPRESENTATIVE HABITAT COMPLEXES ALONG THE MAROS (MUREŞ) RIVER

*Margóczi K., Drăgulescu C., Macalik K. and, Makra O.*

**Abstract**

Detailed identification and description of still existing natural or semi natural habitat complexes is necessary to planning conservation strategies, or restoration programs of deteriorated riverside habitats. The Maros River with its 768-km length is the most important tributary of the Tisa River. Since 1991 Hungarian and Rumanian non-governmental organisations has started interdisciplinary research to assess the common river's environmental condition. On the base of this pilot research 4 representative and highly natural areas has been selected for more detailed scientific investigations: (1) peat bog at Vasláb/Voşlobeni in Giurgeu (Gyergyói) basin, (2) lower Mureş/Maros pass between Ilia and Deva, (3) Pécska/Pecica-Bezdin forest, (4) Maros section in Hungary. Cenological relevés were made in 5-6 representative and natural or semi natural vegetation stands. A description and comparative evaluation of the river valley vegetation were made on the base of these relevés.

**Keywords:** habitat complexes, river valley vegetation, Maros/Mureş, conservation evaluation.

## Introduction

Eastern and Central European rivers and related habitats play an important role in maintaining the biological diversity of the biogeographical regions, not only because of their corridor function, but because they are rich core areas of ecological networks (Gallé et al. 1995, IUCN 1995).

European policy toward flood control is being revised, and provides major opportunities toward nature development or restoration (PEBLDS, 1996).

Detailed identification and description of still existing natural or semi-natural habitat complexes is necessary to plan conservation strategies, or restoration programs of deteriorated riverside habitats. The Maros River with its 768-km length is the most important tributary of the Tisa River. It crosses several relief features with varying lithological structures and its valley includes several various habitat complexes with rich flora, fauna and diverse vegetation. Drăgulescu (1995) presents an enumeration of the flora and vegetation of the Mureş River valley. He refers 1846 taxa of plants, 174 plant associations, and points out, that the Maros valley is now moderately degraded by human activity. The rate of degradation increases from the springs to the river mouth.

Since 1991 Hungarian and Romanian non-governmental organisations have started interdisciplinary research to assess the common river's environmental condition (Hamar & Sárkány-Kiss, 1995). On the base of this pilot research 4 representative and highly natural areas have been selected for more detailed scientific investigations.

## Materials and methods

Botanical field sampling

Cenological relevés were made in 5-6 representative and natural or semi-natural vegetation stands. The areas of the plots were 5x5 m in grasslands, and 20x20 m in forests. The percent coverage of plant species was detected.

A description and comparative evaluation of the river valley vegetation were made on the base of these relevés. The cenological identification of plant association was made according to of Borhidi & Sánta (1999) and Sanda et al. (1980).

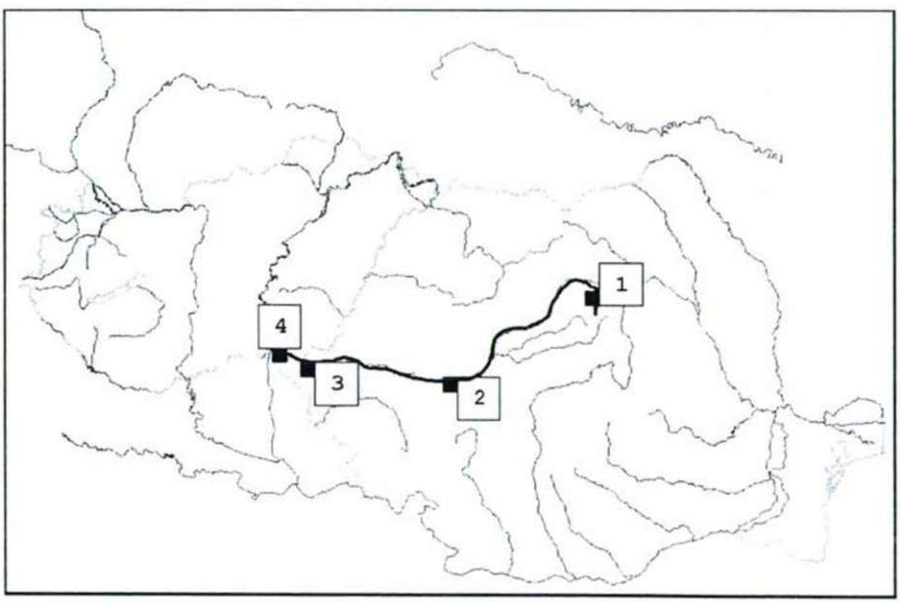



Fig. 1. The study sites along the river Mureş/Maros. 1. Peat bog at Vasláb/Voşlobeni in the Giurgeu (Gyergyói) basin 2. Lower Mureş/Maros pass between Ilia and Deva 3. Pécska/Pecica-Bezdin forest, 4. Maros section in Hungary

**Study sites (Fig. 1.)**

| | Study site | Year of field investigations |
|---|---|---|
| | Peat bog at Vasláb/Voşloben in Giurgeu (Gyergyói) basin | 1999 |
| | Lower Mureş/Maros pass between Ilia and Deva | 2001 |
| | Pécska/Pecica-Bezdin forest | 2000 |
| | Maros section in Hungary | 2001 |

## Results

Description of the study areas

Peat bog at Vasláb/Voşlobeni in the Giurgeu (Gyergyói) basin

The several streams coming in to the basin formed a fen area with two peat bog patches. A thick *Sphagnum* layer covers these two patches and a sparse stand of *Picea abies,* and *Betula pubescens* trees grows here. The peat bog patches are surrounded by large sedges, which are rich in typical fen plant species. The next zone in a slightly higher elevation is the fen meadow, used mainly by mowing. There are dry pastures in the relatively highest areas of the basin. The vegetation of the studied area is very rich and diverse. The composition and pattern of plant associations seems to be rather undisturbed.

Investigated habitats: peat bog and fen (mainly *Carici stellulatae* and *rostratae-Sphagnetum, Caricetum rostratae, Caricetum flavae juncosum subnodulosi,* and *Filipendulo-Geranietum palustris*), wet meadows (*Molinietum coeruleae* and *Agrostio - Deschampsietum caespitosae*), and a dry pasture (*Agrostio - Festucetum rubrae*).

(1) Lower Mureş/Maros pass between Ilia and Deva

The river valley is very narrow, a main road and a railway line are driven here. Most of the area is under agricultural use; the rate of natural habitats is very low. Several plant species of mountain habitats occur occasionally in the river valley.

Investigated habitats: riverside, species rich willow forest *(Salicetum albae-fragilis),* a wet meadow with furze willow *(Salix cinerea, Lythrum salicaria, Inula helenium)* an abandoned arable land, revegetated mainly with non-weed, native species, a rather degraded pasture, and a mountain pasture.

(2) Pécska/Pecica-Bezdin forest

The river is only slightly channelled; it builds and destroys shoals and banks. Different successional stages of natural habitat types are well developed. Most of the forests grow up in natural way after cutting, the forest management is not intensive.

Investigated habitats: the oak-ash-elm forests *(Fraxino pannonicae-Ulmetum)* have high natural value, with species rich, natural undergrowth. The willow and poplar forests *(Salicetum albae-fragilis)* are valuable as well. The sodic oak forest and its glade *(Peucedano officinalis-Asteretum sedifolii)* are such a habitat, which is highly protected in Hungary.

(3) Maros section in Hungary

The river is artificially channelled; the dikes separate the inundation area. There are no forests outside the dikes. The planted forests in the inundation area are intensively managed, the natural undergrowth is eliminated at plantation of the forests. The rate of hybrid poplar plantation is rather high. The rate of really old oak, white poplar and willow forest is rather low. The invasive tree species are abundant. Some native and protected plant species occur sporadically. Most of the inundation area is under protection, and habitat reconstruction is planned.

Investigated habitats: old poplar-willow forests *(Salicetum albae-fragilis)*, several planted forests *(Populus canescens, Populus x hybrida, Quercus robur)*, foxtail meadow *(Alopecuretum pratensis)*, grassland on the dike, forest belt.

## Discussion

These 4 study sites do not represents all of the habitat types and the whole flora and vegetation of the Mureş valley, but they give a certain picture about the long and very diverse river from the upper section till the estuary.

The peat bog and fen area at Voşlobeni is a highly natural, rich and diverse. Detailed botanical description of occuring habitats is presented by Margóczi et al. (2000). The present human uses of the grasslands, that is moderate grazing and mowing, do not endanger considerably the natural values, but the nature protection and detailed mapping of this very important natural habitat is necessary and urgent! A similar peat bog basin has been drained 50 years ago near to this place. The agricultural use of the area is not very successful, but the unique natural values have disappeared.

In the narrow river valley in the lower Mureş pass most of the area is under agriculture, or serving the big traffic, so the few semi-natural habitats are very important for maintaining regional biodiversity. The investigated secondary habitats seemed to be rather rich in natural plant species, the mountain species often occur, the corridor function of the river seems to be working.

Comparison of the two study sites in the Romanian and Hungarian part of the Mureş floodplain clearly demonstrate the effect of human use on reverine habitats. The river is highly channelled in the Hungarian part, flows in a straight, artificial bed, so the natural habitat dynamics of the building and falling banks does not work. In the Romanian section a lot of different natural, successional stages of riverine habitats develop. The other big difference is in the management of forests. In the Hungarian part the forests are artificially planted and intensively managed. The main tree species is the exotic hybrid poplar. There are native oak, poplar and willow forests, but their grass layer is very poor. The unnatural inundation regime inside the dikes does not allow the survival of several natural species. In the Rumanian part the forests regrow in a natural way after cutting, and the hydrological situation is much more natural. The species rich and highly natural forests in the Romanian part could be the reference sites for habitat restoration experiments in Hungary.

## References

Borhidi A. & Sánta A. (eds.) (1999): Vörös Könyv Magyarország növénytársulásairól - TermészetBúvár, Budapest.

Dragulescu, C. (1995): The flora and vegetation of the Mureş (Maros) valley - In Hamar J., & Sárkány-Kiss A. (1995): The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. - Szolnok, Szeged, Târgu Mureş, pp. 47-112.

Gallé, L., Margóczi, K., Kovács, É., Györffy, Gy., Körmöczi, L., and Németh, L.: River valleys: Are they ecological corridors? - Tiscia 29, 53-58.

Hamar J., & Sárkány-Kiss A. (1995): The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. - Szolnok, Szeged, Târgu Mureş, pp.257.

IUCN (1995): River corridors in Hungary: A Strategy for the conservation of the Danube and its tributaries (1993-94), IUCN, Gland, Switzerland and Budapest, Hungary, 124 pp.

Margóczi K., Dragulescu C. and Macalik K. (2000): Vegetation description of representative habitat complexes along the Maros (Mureş) River I. The upper section (Vasláb/Voslobeni). In Gallé L. & Körmöczi L. eds.: Ecology of River Valleys, Szeged.

PEBLDS (Pan-European Biological and Landscape Diversity Strategy) (1996) - Council of Europe, UNEP, ECNC.

Sanda, A., Popescu, A., Doltu, M.I., (1980):- Cenotaxonomia si corologia gruparilor vegetale din Romania, St. si com. Muz. Brukenthal, Sibiu, St. nat., 24 Suppl.

MARGÓCZI K.
Makra O.
Department of Ecology, University of Szeged, Szeged, Pf. 51. H-6701, Hungary
margoczi@bio.u-szeged.hu

DRĂGULESCU C.
Lucian Blaga University, Sibiu, Romania
31 Oituz St., 2400 Sibiu, RO

MACALIK K.
Babes-Bolyai University, Department of Ecology and Genetics
5-7 Clinicilor St., 3400 Cluj, RO
maca@biolog.ubbcluj.ro



SZTE Egyetemi Könyvtár
SZEGED
3.

TISCIA monograph series (2002), 6, 51-62

# SOME ASPECTS OF THE MODIFICATIONS OF THE AQUATIC OLIGOCHAETA FAUNA IN THE CRIŞURI RIVERS BETWEEN 1994-1998

*Diana Cupşa*


## Abstract

The aquatic oligochaeta were studied in the Crişuri Rivers between 1994-1998 in two research campaigns. In this paper we compare the results of the two campaigns and we apreciate the evolution of the oligochaeta fauna from the Crişuri Rivers according to the environmental modifications.

We observed that in the most river parts the number of the species decreased and sometimes their density increased. This fact is probably due to the higher organic pollution of the river portions in certain periods of time.


**Keywords:** oligochaeta, benthic fauna, diversity.

## Introduction

The composition of the living organism communities in a certain environment reflects the quality of this environment. The changes in the species association reflect natural or anthropic modifications in the environment, modifications which determine the settlement or the disappearance of certain species.

The effects of the modifications can be short like oxigen depletion or longer like heavy metal pollution, and they determine injuries of the zoocoenoses, which will resettle in a longer time (A. Szitó, K. Mózes, 1997).

We tried to compare the aquatic oligochaeta fauna from the Crişuri rivers in the different years of study as follows: Crişul Alb 1994, 1997, 1998; Crişul Negru 1994, 1996, 1997, 1998 and Crişul Repede 1995, 1996, 1997, 1998. The material from 1994 and 1995 was collected by a campaign organised by Tisza Klub (Szolnok, Hungary) and Liga Pro Europa (Târgu Mureş, Romania). The results of this campaign were published in the Tiscia Monograph Series, The Criş/ Körös Rivers' Valleys, 1997. The material from 1996-1998 was collected by myself.

The sampling sites in the two campaigns were not all the same, so we compared the oligochaeta fauna from the matching sites on each river.

These were the follows: Crişul Alb: Brad, Aciuţa, Chişineu-Criş; Crişul Negru: Ştei, Tinca, Zerind; Crişul Repede: Şaula, Ciucea, Stâna de Vale, Vadu Crişului, Aleşd, Fughiu. The sample sites were described in a previous paper (A. Sárkány-Kiss, N. Găldean, N. Mihăilescu, 1997).

The goals were to apreciate the modifications of the aquatic oligohaeta community in the years of study, to appreciate the effects of the environmental changes on the aquatic oligochaeta and to forecast the future evolution of the aquatic oligochaeta community.

## Material and methods

The samples were taken by a hand net with 250 μm pore mesh size. The sediment was collected near the banks on the right and left sides and in the main current.

Each sample was washed through a metal screen with a pore mesh size of 250 μm after collection and preserved in 3-4% formalin solution. The oligochaeta were separated from the sediment under a stereomicroscope with a four to sixfold magnification. Animals were preserved in 80% ethylalcohol.

For the taxonomical identification the following works were used: Brinkhurst 1963; Brinkhurst and Jamieson 1971; Ferencz 1979; Pop V. 1943, 1950.

## Results

Crişul Alb River

At Brad in 1994 the number of species and the density of the oligochaeta was bigger than in the following years when we found two species (7 in 1994) and a density under 1000 ind./m$^2$. We found almost exclusively Tubificidae species. *Limnodrilus claparedeianus* and *Potamothrix isochaetus* were dominant. Only in 1997 we found one Naidid species: *Spercaria josinae.*

At Aciuţa we also found in 1997-1998 fewer species (1-2) than were found in 1994, but the density of the individuals is closer in the three years of study (Table 1). Dominant in 1997-1998 was *Limnodrilus claparedeianus* and in 1994 *Limnodrilus hoffmeisteri.*

At Chişineu-Criş in 1997 and 1998 we did not find any of the species found in 1994, but the density and the number of species were very alike in these years.

The number of species founded along the total number of sample sites of the Crişul Alb River (5 sites in 1994 and 12 in 1997-1998) were 11 in 1994 and 14 in 1997-1998, from which 5 species are common in the whole period of study: *Nais behningi, Nais pseudoptusa, Pristina rosea, P. bilobata, Limnodrilus claparedeianus.*

The diversity is the highest in 1994 in all three sample sites (Fig. 1). In the next period the diversity drops in all sample sites and in 1998 at Aciuţa it is zero, as well as in 1997 at Chişineu-Criş.

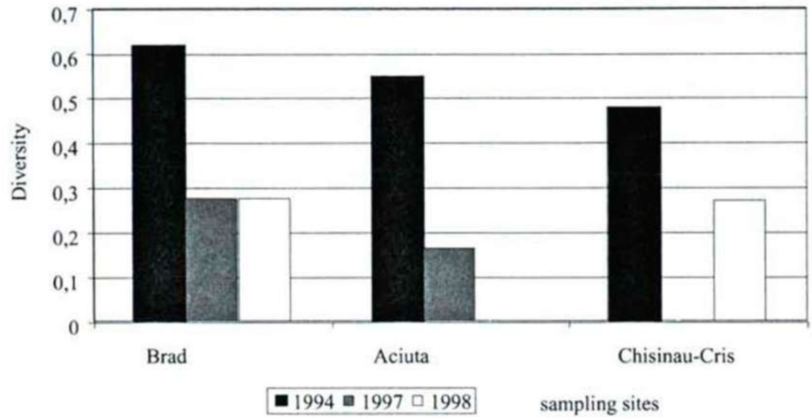



**Fig.1. Comparative diversity of the oligochaeta fauna in the Crişul Alb River as a living resource in 1994, 1997, 1998. (Shannon-Wiener div. Index)**

Crişul Negru River

At Ştei in 1994 the highest density and number of species (2809 ind./m$^2$ and 6 species) was found (Table 2). The situation was similar in 1996 when we also found 6 species and their density was around 2300 ind./m$^2$. In 1997 and 1998 the density and the number of species decreased very much as compared to the previous years situation, to 3 species and a density below 1500 ind./m$^2$.

At Tinca there is the only site along the river where in 1994 only one species *Branchiura sowerbyi* was found, but in the following years we found 4 to 7 species with a high density of the individuals, above 4500 ind./m$^2$.

At Zerind the number of species and the density of the aquatic oligochaeta were very similar in all the studied years, although the found species weren't the same ones in these years.

The number of species founded along the total number of sampling sites on the Crişul Negru River (9 sites in 1994 and 8 sites between 1996-98) were 16 in 1994 and 13 between 1996-98. The common species in these years are 8: *Nais behningi, N. bretscheri, Pristina aequiseta, P. bilobata, Vejdovskyella comata, Branchiura sowerbyi, Limnodrilus claparedeianus, Tubifex newaensis.*

The diversity in the compared sample sites varies in the 4 years of study. At Ştei the highest diversity was in 1994 (Fig. 2), in 1996 the diversity was almost the same as in 1994, but in 1997 it drops to 0,142 and in 1998 increases again.

At Tinca in 1994 the diversity was zero, in 1996 was as low as 0.054, but in 1997-98 it has improved (Fig. 2).

At Zerind the diversity is the most constant. 0.3 in 1994, 0.451 in 1996-97 and 0.384 in 1998.

**Table 1. Quantitative data of the Oligochaeta in the River Crişul Alb in 1994, 1997, 1998.**

| | Brad | | | Aciuţa | | | Chişineu Criş | | | Tot. | Tot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1994 | 1997 | 1998 | 1994 | 1997 | 1998 | 1994 | 1997 | 1998 | Sp. 94 | Sp. 97-98 |
| Amphichaeta leydigii | | | | | | | | | | - | + |
| Spercaria josinae | | 106 | | | | | | | | - | + |
| Nais behningi | | | | 20 | | | 30 | | | + | + |
| N. bretscheri | | | | | | | | | | + | - |
| N. communis | 386 | | | | | | | | | + | - |
| N. pseudoptusa | | | | | | | | | | + | + |
| N. variabilis | 214 | | | | | | | | | + | - |
| Pristina rosea | | | | | | | | 109 | 58 | + | + |
| P. bilobata | 686 | | | 241 | 118 | | | | | + | + |
| P. aequiseta | | | | | | | | | | - | + |
| Uncinais uncinata | 86 | | | | | | | | | + | - |
| Limnodrilus claparedeianus | 171 | | 399 | 302 | 680 | 1106 | 40 | | | + | + |
| L. hoffmeisteri | 2313 | | | 845 | | | 30 | | | + | - |
| L. profundicola | 428 | | | 181 | | | | | | - | - |
| Isochaeta virulenta | | | | | | | | | | - | + |
| Potamothrix isochaetus | | 193 | 204 | | | | | | 102 | - | + |
| P. vejdovskyi | | | | | | | | | | - | + |
| Peloscolex velutina | | | | | | | | | | - | + |
| P. speciosus | | | | | | | | | | - | + |
| Rhyacodrilus falciformis | | | | | | | | | | - | + |
| Total (ind/m$^2$) | 4284 | 299 | 603 | 1589 | 798 | 1106 | 100 | 109 | 160 | - | - |
| Total sp. | 7 | 2 | 2 | 5 | 2 | 1 | 3 | 1 | 2 | 11 | 14 |

**Table 2. Quantitative data of the Oligochaeta in the River Crişul Negru in 1994, 1996, 1997, 1998.**

| Specii | Ştei | | | | Tinca | | | | Zerind | | | | Tot. | Tot. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1996 | 1997 | 1998 | 1994 | 1996 | 1997 | 1998 | 1994 | 1996 | 1997 | 1998 | Sp. 94 | Sp. 96-98 |
| Nais barbata | 219 | | | | | | | | | | | | + | - |
| N. behningi | | 203 | 803 | 201 | | 351 | | | 557 | | | | + | + |
| N. bretscheri | 619 | | | 97 | | | | | 10 | | | | + | + |
| N. communis | | | | | | | | | | | | | + | - |
| N. pseudoptusa | | | | | | | | | | | | | + | - |
| Pristina aequiseta | | | 251 | | | 52 | | | 10 | 206 | | | + | + |
| P. bilobata | | 1106 | 198 | | | 138 | | | | | 108 | 81 | + | + |
| P. rosea | | | | | | | | | | | | | + | - |
| Vejdovskyella comata | | 49 | | | | | | | | | | | + | + |
| Uncinais uncinata | 109 | | | | | | | | | | | | + | - |
| Slavina appendiculata | | | | | | | | | | | | | - | + |
| Spercaria josinae | | 550 | | | | 616 | 106 | 104 | | | | | - | + |
| Branchiura sowerbyi | | | | | 59 | | 501 | 406 | | | | | + | + |
| Potamothrix vejdovskyi | | 98 | | | | 1405 | 486 | 1105 | | 92 | | | - | + |
| Isochaeta michaelseni | | | | | | 48 | 4384 | 2893 | | | 199 | 399 | - | + |
| Limnodrilus claparedeianus | 401 | 347 | | 104 | | 2991 | | | | 103 | 96 | 153 | + | + |
| L. hoffmeisteri | 987 | | | | | | | | 182 | | | | + | - |
| L. profundicola | | | | | | | | | | | | | - | + |
| Tubifex newaensis | | | | | | | 198 | | | | | | + | + |
| T. tubifex | 474 | | | | | | | | | | | | + | - |
| Eiseniella tetraedra | | | | | | | | | | | | | + | - |
| Total (ind/m$^2$) | 2809 | 2353 | 1252 | 402 | 59 | 5601 | 5675 | 4508 | 759 | 401 | 403 | 633 | - | - |
| Total species | 6 | 6 | 3 | 3 | 1 | 7 | 5 | 4 | 4 | 3 | 3 | 3 | 16 | 13 |

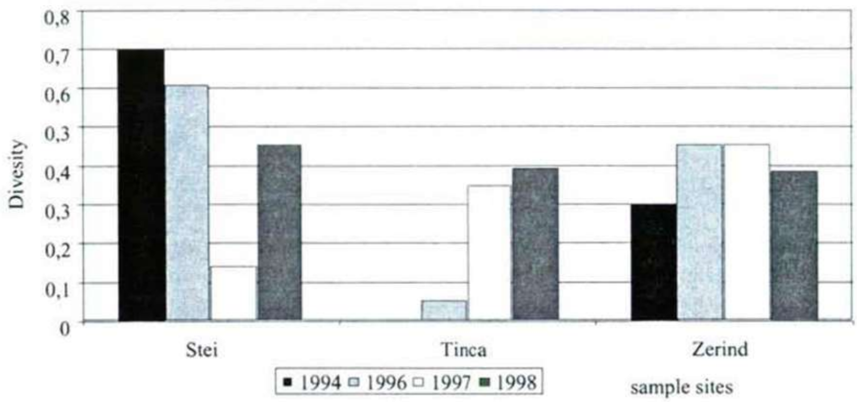



**Fig.2. Comparative diversity of the oligochaeta fauna in the Crişul Negru River as a living resource in 1994, 1996-1998. (Shannon-Wiener div. Index)**

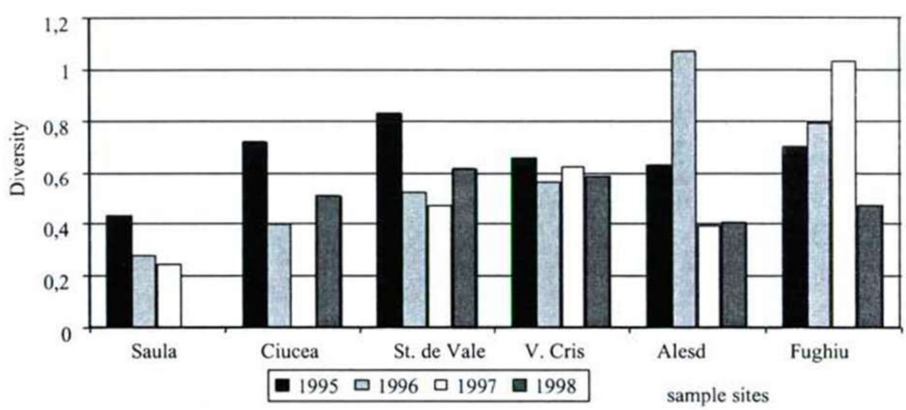



**Fig. 3. Comparative diversity of the oligochaeta fauna in the Crişul Repede River as a living resource in 1995-1998. (Shannon-Wiener div. Index)**

Crişul Repede River

In 1995 the number of species was higher than in the following years. In the first 5 sample sites the differences between the number of species are high, in 1995 there were found more than the double of the species than in the following years. But the situation of the density is different because we registered sites (Ciucea, Vadu Crişului, Aleşd) were the density increased between 1996-1998, although the number of species decreased.The smallest difference is at Fughiu where except 1998, when we found only 3 species in the previous years, the number of species is almost the same (between 8 and 10) (Table 3). At this sample site the density of the oligochaeta is much higher in 1996-1998 than in 1995. The total number of species found in all sampling sites along the river ( 8 in every year of study) was 25 in 1995 and 24 between 1996-98. The common species were 13: *Nais barbata, N. behningi, N. bretscheri, N. pseudoptusa, Vejdovskyella* *comata, Stylaria lacustris, Pristina bilobata, P. rosea, P. aequiseta, Branchiura sowebyi, Limnodrilus claparedeianus, L. hoffmeisteri, L. udekemianus.*

The diversity of the oligochaeta in the four years of study varies, it is lower between 1996-98 than in 1995 (Fig. 3) at Şaula, Ciucea, Stâna de Vale, and Vadu Crişului. At Aleşd in 1996 the diversity is higher than in 1995, but in the following years it decreases. At Fughiu in 1996 and 1997 it is higher than in 1995, and in 1998 it is lower.

## Discussion

In the Crişul Alb River the high density of the oligochaeta at Brad in 1994 is probably due to the organic material content and the quantity of the inorganic phosphorus which determine the biomass of the primary production, the main food source of the worms (A. Szitó, K. Mózes, 1997). The decrease of the density and the number of species in the following years is probably due to the decrease of the inorganic phosphorus quantity or a higher flow of the water which can wash away the phosphorus, the organic matter and also the worms.

At Aciuţa the number of species is lower in 1997-98, but we found the same species as in 1996, with lower densities. Here the river is cleaner than at Brad and the lower organic content does not allow the settlement of too many species.

At Chişineu-Criş we found in the three years of study different species but the same low density. This is due to the fact that in this sector the river banks are endammed and the riverbed is very uniform. Also, the muddy and sandy riverbed is moved by the current so the benthic fauna cannot consolidate here. For this reason, the species found here, in the different years are not the same and their density is low.

The existence of only five common species found in the different years of study, reflects the fact that the aquatic oligochaeta in the Crişul Alb River is not well consolidated, it varies a lot, due to the fact that the river crosses many localities which can pollute the river with organic or inorganic materials, affecting the quality of the water and the benthic communities.

On the Crişul Negru River at Ştei the quality of the water is poor due to the organic wastes eliminated from the locality in the river. This fact determines a higher density of aquatic oligochaeta which have good trophic conditions at this sample site. In 1998 the water quality seems to improve because the density of the oligochaeta drops abruptly (Table 2).

At Tinca we found great differences between the oligochaeta identified in 1994 and 1996-1998, regarding the number of species as well as the density. In 1994 was found a single species *Branchiura sowerbyi* with a low density of individuals. This species is a thermophylic and pelophylic one and it was found in almost all research period. During 1996-98 the number of the species was higher (4 to 7 species) with a higher density, fact which is probably due to the higher organic content in the river in this period which offers a good trophic base to the oligochaeta. Some of the species could be carried here from upstream by the water from the regions where the water speed is higher and can wash the substratum, especially in the periods with high flows. At Tinca the water flows slower and the oligochaeta can be deposited in the riverbed.

**Table 3. Quantitative data of the Oligochaeta in the River Crişul Repede in 1995-1998.**

| 1 | | Şaula | | | | Ciucea | | | | St.Vale | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Specii | 95 | 96 | 97 | 98 | 95 | 96 | 97 | 98 | 95 | 96 | 97 | 98 |
| 3 | Chaetogaster diastrophus | | | | | | | | | | | | |
| 4 | Ch. langi | | 106 | 296 | | | | | | | | | |
| 5 | Spercaria josinae | | | | | | 502 | | 611 | | 206 | 150 | |
| 6 | Aulodrilus pigueti | | | | | | | | | | | | |
| 7 | A. pluriseta | | | | | 2 | | | | | | | |
| 8 | Uncinais uncinata | | | | | | | | | | | | |
| 9 | Nais barbata | | | | | 4 | | | | 325 | | | |
| 10 | N. behningi | | | | | | 150 | | 204 | 104 | 103 | 102 | 402 |
| 11 | N. bretscheri | | | | | 138 | | | | 207 | | | 110 |
| 12 | N. communis | | | | | 274 | | | | 380 | | | |
| 13 | N. elinguis | | | | | 8 | | | | 147 | | | |
| 14 | N. pardalis | | | | | | | | | 484 | | | |
| 15 | N. pseudoptusa | | | | | 30 | | | | 573 | | | |
| 16 | N. variabilis | | | | | | | | | | | | |
| 17 | Slavina appendiculata | | | | | | | | | | | | |
| 18 | Ophidonais serpentina | | | | | | | | | 70 | | | |
| 19 | Vejdovskyella comata | | | | | | | | | | | | |
| 20 | Stylaria lacustris | | | | | | | | | | | | |
| 21 | Piguetiella blanci | | | | | | | | 98 | | | | 96 |
| 22 | Dero obtusa | | | | | | | | | | | | |
| 23 | Pristina rosea | | | | | 16 | | 109 | | | | | |
| 24 | P. bilobata | | | | | 8 | | | | | | | |
| 25 | P. aequiseta | | | | | 14 | | | | | 51 | | 102 |
| 26 | Rhynchelmis sp. | | | | | | | | | 35 | | | |
| 27 | Stylodrilus heringianus | 14 | | | | | | | | | | | |
| 28 | Tubifex tubifex | 859 | | | | 6 | | | | | | | |
| 29 | Tubifex newaensis | | | | | | | | | | | | |
| 30 | Branchiura sowerbyi | | | | | | | | | | | | |
| 31 | Limnodrilus claparedeianus | 328 | 58 | | 103 | | 144 | | 205 | | 99 | | 205 |
| 32 | L. hoffmeisteri | 3443 | | 98 | | 56 | | | | | | 98 | |
| 33 | L. profundicola | 11 | | | | | | | | | | | |
| 34 | L. udekemianus | 439 | | | | | | | | | | | |
| 35 | Psammorycrtides moravicus | | | | | | | | | | | | |
| 36 | Ps. albicola | | | | | | | | | | | | |
| 37 | Potamothrix vejdovskyi | | | | | | | | | | | | |
| 38 | Eiseniella tetraedra | | | | | | | | | 15 | | | |
| 39 | Total (ind/m$^2$) | 5094 | 164 | 394 | 103 | 556 | 796 | 109 | 1118 | 2340 | 459 | 352 | 915 |
| 40 | Total species | 6 | 2 | 2 | 1 | 11 | 3 | 1 | 4 | 10 | 4 | 3 | 5 |

| 1 | V.Criș | | | | Aleșd | | | | Fughiu | | | | Tot. | Tot. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 95 | 96 | 97 | 98 | 95 | 96 | 97 | 98 | 95 | 96 | 97 | 98 | Sp. 95 | Sp. 96-98 |
| 3 | | | | | | 101 | | | | | | | - | + |
| 4 | | | | | | | | 105 | | | | | - | + |
| 5 | | 202 | 294 | 201 | | 196 | 108 | 191 | | 506 | 608 | | - | + |
| 6 | | | | | | | | | 7 | | | | + | - |
| 7 | 13 | | | | | | | | | | | | + | - |
| 8 | | | | | | | | | | | 95 | | - | + |
| 9 | 7 | | | | 73 | | | | | | | | + | + |
| 10 | 16 | | 795 | 199 | 119 | | | | | 250 | 204 | | + | + |
| 11 | 312 | | 101 | | 1295 | | | | | | | | + | + |
| 12 | 86 | | | | 123 | | | | 20 | | | | + | - |
| 13 | 23 | | | | 53 | | | | | | | | + | - |
| 14 | 19 | | | | 377 | | | | 3 | | | | + | - |
| 15 | 73 | | 204 | | 103 | | | | | | | | + | + |
| 16 | | | | | 3 | | | | | | | | + | - |
| 17 | | | | | | | | | | | | | - | + |
| 18 | 7 | | | | | | | | 51 | | | | + | - |
| 19 | | | | 103 | | | | | 3 | 98 | | 204 | + | + |
| 20 | | | | | 12 | | | | 88 | | | | + | + |
| 21 | | | | | | | | | | 496 | 351 | 803 | - | + |
| 22 | | | | | | | | | | | | | - | + |
| 23 | | | | | 3 | | 396 | 209 | | | 108 | 968 | + | + |
| 24 | 6 | 97 | 98 | | 17 | | | | 7 | 311 | 791 | | + | + |
| 25 | | | 103 | | 10 | | | | | 105 | 401 | | + | + |
| 26 | | | | | | | | | | | | | + | - |
| 27 | | | | | | | | | | | | | + | - |
| 28 | 13 | | | | 46 | | | | 3 | 101 | | | + | - |
| 29 | | | | | | | | | | 803 | 750 | | - | + |
| 30 | | | | | | | | | 3 | | | | + | + |
| 31 | 6 | | | 204 | | | | | | | | | + | + |
| 32 | | 301 | | | 12 | 998 | 3402 | 2989 | 17 | | | | + | + |
| 33 | | | | | | | | | | | | | + | - |
| 34 | | | | | | | | | | | | | + | + |
| 35 | | 103 | | | | | 550 | 795 | | | | | - | + |
| 36 | | | | | | | 197 | | | | | | - | + |
| 37 | | | | | | | | | | | | | - | + |
| 38 | | | | | 13 | | | | | | 100 | | + | - |
| 39 | 581 | 703 | 1595 | 707 | 2259 | 1295 | 4653 | 4289 | 202 | 2670 | 3480 | 2080 | | - |
| 40 | 12 | 4 | 6 | 4 | 15 | 3 | 5 | 5 | 10 | 8 | 9 | 3 | 25 | 24 |

At Zerind the number of species and their density do not vary too much, but the found species were different in the studied years. The reason for this fact is the same as mentioned at Chişineu-Criş: the enbankment of the river and the moving substrate which does not allow the oligochaeta community to consolidate.

In the Crişul Negru River we found 8 common species for the two study periods, which represent half of the total species found in the river. This reflects the fact that the river has a basic structure of oligochaeta on which the associations can build up.

In the Crişul Repede River at Şaula the density and the number of species decrease between 1996-1998 as compared to 1995, but the Tubificidae species are also dominant, fact which reflects a high organic content of the water at this sample site.

At Ciucea the situation of the number of species is similar to that found at Şaula, the density increases in 1996 and 1998, but here the Naididae species are dominant, fact which reflects an improving water quality compared to the Şaula sample site.

At Stâna de Vale and Vadu Crişului the number of species decreases between 1996-98 compared to 1995, but at Vadu Crişului the density increases in the same period. At these two sample sites the dominant oligochaeta are also the Naididae. Here the water quality is relatively good, with a small organic content.

At Aleşd the number of species decreases between 1996-98 but the density is higher in 1997 and 1998 than in 1995 and 1996. Here the dominant species are also the Naididae.

At Fughiu the differences between the number of species is not so high between 1995-97, but it drops in 1998. The density is much higher between 1996-98 than in 1995. The modifications of the number of species and their density along the Crişul Repede River is due probably to the hydrological regime of the water, the great number of dammed portions which function as water reservoirs and from where the water is cleared out in the dry periods of the year to ensure the water supply for the localities along the Crişul Repede River. These modifications in the hydrological conditions can wash away a part of the oligochaeta fauna and cause the mentioned modifications.

The total number of species found in 1995 was 25 and between 1996-98 it was only 24. The common species from these years in the river are 13. This reflects the fact that the oligochaeta community along the Crişul Repede River has a basis of species around which the associations consolidate.

## Conclusions

Along the Crişuri rivers we found during the mentioned study years great modifications concerning the number of species and their density. These modifications are caused by the different levels of pollution in the different years, the different hydrological regimes and the characteristics of the life cycles of each species.

The diversity of the oligochaeta is generally low, in some places equal to zero in some periods (Şaula 1998, Ciucea 1997, Tinca 1994, Aciuţa 1998, Chiţineu-Criş 1997).

The number of species along the rivers have a little variation between the years of study with the exception of the major part of the Crişul Repede River, but we found different species in different years in the same sample sites.

In the most upstream river portions the Naididae species are dominant, which reflects a better water quality than in the lower portions where the Tubificidae are dominant.

Because in the studied period we did not register major environmental modifications in the rivers we consider that it is necessary to follow the modifications of the oligochaeta fauna during several years on a long term period, to find out all the factors which contribute to the modifications of the species composition and density of the oligochaeta.

## References


Botea, Fr., (1966): Cercetări asupra faunei de oligochete limicole din interstiţialul Crişului Repede (Valea Porcului) (Investigations on oligochaeta fauna of the river Crişul Repede (Valley Porcului) from the interstitial water). – Lucr. Instit. Speol. "Emil Racoviţă", 5: 75-80.

Botea, Fr., Pleşa, C., (1968): Cercetări asupra faunei interstiţiale din Bazinul Crişului Repede (Investigations on the interstitial fauna of the River Crişul RepedeValley). – Lucr. Instit. Speol. "Emil Racoviţă", 8: 196-215.

Brinkhurst, R. O., (1963): A guide for the identification of British aquatic Oligochaeta. – Freshwat. Biol. Assoc. Sci. Publ. 22: 1-52.

Brinkhurst, R. O. & Jamieson, B. G. M., (1971): Aquatic oligochaeta of the world. - Oliver and Boyd, Edinburgh, 1-860.

Chapman, P. M., Farrell, M. A., Brinkhurst, R. O., (1982). - Relative tolerances of selected aquatic oligochaetes to combinations of pollutants and environmental factors. - Aquat. Toxycol., 2: 69-78.

Cupşa, D., (1997): Aspecte privind compoziţia specifică a faunei bentonice din bazinul superior al Crişului Negru (Aspects of the specific composition of the benthic fauna from the superior basin of the Crişul Negru River). - An. Univ. Oradea, Fasc. Biologie, 4: 56-63.

Cupşa, D., (1998): Aspecte privind structura comunităţilor de oligochete acvatice din râul Crişul Repede (Aspects concerning the structure of the aquatic oligochaeta communities in the Crişul Repede River). - An. Univ. Oradea, Fasc. Biologie, 5: 91-100.

Cupşa, D., (2000): Some comparative aspects of the aquatic Oligochaeta distribution in the Crişul Negru river, during 1996-1997 . - Acta oecologica, Stud. comunic. Ecol. prot. med., vol.VII, 1-2: 41-48.

Cupşa, D., (2000): Contribuţii la studiul oligochetelor acvatice din râul Crişul Alb (Contributions to the study of the aqautic oligochaeta from the Crişul Alb River). - Stud. Cerc. Ştiinţif., Univ. Bacău, 5: 183-189.

Draganovici-Duca, M., (1967): Cercetări biologice privind calitatea apei unor râuri din bazinul Crişuri, (Biological researches on the quality of some rivers from the Crişuri Valley). - Stud. Prot. şi Epur. Apelor, 8: 70-83.

Ferencz, M., (1979): A vizi kevessertéjü gyürüsférgek (Oligochaeta) kishatározója (A guide for the identification of aquatic Oligochaeta) - Vizügyi Hidrobiológia, Budapest, 7: 7- 167.

Marcoci, S., (1962): Utilizarea studiilor biologice pentru caracterizarea calităţii cursurilor de apă cu aplicaţii la râul Trotuş, (The utilisation of the biological studies for the characterisation of the qaulity of the water courses with aplications on Trotuş River). - Metro. Hidro. Gosp. Ape.,: 282-287.

Marcoci, S., Duca, M., Botea, Fr., (1966): Consideraţii asupra importanţei oligochetelor în caracterizarea stării de murdărie a apelor, (The importance of the Oligochaeta in the determination of the pollution level of the river water). - Stud.Prot. Epur. Ape., 7-2: 680-693.

Mălăcea, I., (1969): Biologia apelor impurificate, (The biology of the polluted rivers) - Ed. Acad. R. S. R., Bucureşti.

Pleşa, C., Botea, Fr., Racoviţă, Gh., (1964): Cercetări asupra faunei biotopurilor acvatice subterane din bazinul Crişului Repede, I, Valea Mişidului şi afluentii, (Researches on the fauna of the subteran aquatic biotopes from the Crişul Repede Valley, I, Mişidului Valley and its tributaries) - Lucr. Inst. Speol. "E.. Racoviţă" 3: 367-396.

Pop, V., (1943): Einheimische und auslandische Lumbriciden des Ungarischen National-Museums in Budapest. – Ann. Nat. Hist. Mus. Hung., 36: 12-24.

Pop, V., (1977): Neue Tubificiden (Oligochaeta, Annelida) aus Rümanien. - Stud. Univ. "Babeş-Bolyai", Cluj-Napoca, Ser. Biologia, 1: 47-52.

Sárkány-Kiss, A., Găldean, N., Mihăilescu, N., (1997): Description of the sampling sites along the rivers in the Criş/Körös Basin - TISCIA Monograph series, The Crişuri/ Köröz Rivers Valley, A study of geography, hydrobiology and ecology of the river system and its environment, Ed. Sarkany-Kiss, A., & J. Hamar, Szolnok-Szeged-Tg. Mureş, 7-14.

Szito, A., (1995): Macrozoobenthos in the (Maros) Mureş river - TISCIA Monograph series, The Maros/Mureş River Valley, A study of geography, hydrobiology and ecology of the river system and its environment, Ed. Sarkany-Kiss, A., & J. Hamar, Szolnok-Szeged-Tg. Mureş, 185-192.

Szito, A., Mozes, K., (1997): The Oligochaeta and the chironomid fauna as pollution indicators in the Criş/Körös river system. - TISCIA Monograph series, The Crişuri/ Körös Rivers Valley, A study of geography, hydrobiology and ecology of the river system and its environment, Ed. Sarkany-Kiss, A., & J. Hamar, Szolnok-Szeged-Tg. Mureş 165-194.

Szito, A., Mozes, K., (1999): The Oligochaeta and the chironomida fauna in the River Someş system. - TISCIA Monograph series, The Someş/Szamos River Valley, A study of geography, hydrobiology and ecology of the river system and its environment, Ed. Sarkany-Kiss, A., & J. Hamar, Szolnok-Szeged-Tg. Mureş, pp.179-193.

DIANA CUPŞA
University of Oradea
Faculty of Sciences
Department of Biology
5 Armatei Române St.
3700 Oradea, Romania

TISCIA monograph series (2002), 6, 63-70

# MALACOFAUNISTICAL STUDY OF THE FLOOD-PLAIN OF THE MUREŞ RIVER IN THE ZAM REGION

*Domokos Tamás, Váncsa Klára, Sárkány-Kiss Andrei*

**Abstract**

We have studied the malacofauna of the flood-plain of the Mureş river in the Zam region, using samples taken along a 300 m long transect on the left bank of the river. There were four characteristic biotopes along the transect: Salicetum albae-fragilis, mowed meadow, unmowed meadow and Salicetum cinerea. There were taken eight samples in each biotope, using the quadratic method. Our purpose was to find out, if the four biotopes can be differentiated taking into consideration the malacofauna. In the same time, the migration of species along the transect was also examined.We found that along the transect two fluctuation zones can be differentiated: on the right side of the road, where the species disperse due to the river and to migration, and on the left side of the road, where the species dispersion arises from the nearby forest. The malacofauna indicates the microclimate of the different biotopes. We have represented graphically the quantitative distribution of species and ecological groups, as well as the diversity of the four biotopes. Based on these results, we have established the objectives of future investigations in the region.

**Keywords:** Mureş River, floodplain, malacofaunistical transect.

## Introduction

Our study is part of a research with the target of surveying of the Mureş River valley as an ecological corridor. In the course of the research we accomplished, besides the botanical and the entomological surveys, the malacofaunistical examination of the sampling places, taking into consideration that the malacofauna of a biotope indicates precisely the morphological and the climatic states of the area and gives information about the natural value of the surveyed area.

## Sampling site and method of collection

The survey was accomplished in the flood-plain of the Mureş river in the Zam region, on the verge of Sălciva village, along a North-South transect perpendicular to the river, on its left bank.

The transect encompasses four homogeneous, separated botanical areas with a peculiar microclimate :

a) 50 meters wide grove wood, situated right on the bank, which is rich in plant species, it is a jungle-like domain, interwoven by lianas and less accessible. Its microclimate is humid, cool and vaporous.

b), c) beyond the grove there are cultivated lands, hayfields next to each other, on each side of the transect. On the right side there is the scythed field, which had been scythed a little before our sampling took place, therefore it is a relatively dry, bare area, with hardly sprouting grasses. The field situated on the left had not yet been scythed in the year of our sampling, so it is covered by a vegetation made up of high-grown, aged, grassland gramineae. Its microclimate is cooler, more humid than that of the grassland, because it is a closed domain.

d) the fourth biotope is situated further along the transect, beyond the road which connects the villages Sălciva and Pojoga. The furze-field is a mixed botanical domain: different species can be found there, from the swamp species, through the species living in the mountains, to the common grassland species. Some time ago it was cultivated, but its cultivation was ceased and therefore it has become a domain with high grass, bushes and sedge. Its microclimate is humid, cool.

The furze-field closes the transect, but it is important to mention that beyond it there are grasslands again and finally the flood-plain is closed by the mountain slope covered by forests made up of alder and beech trees.

We took a total of 32 quadrates (25x25cm) of samples, 8 quadrates from each biotope. It is important to mention that the samplings took place at two different times: on the first occasion the weather was sunny, dry and warm, on the second one it was humid and moisty. Consequently, our results were not influenced by the weather.

Because the four biotopes are botanically distinct, our target was to find out whether these differences can or cannot be reflected by the malacofauna. Along the transect we also studied the migration of the species through the flood-plain.

## Results

The sketch of the flood-plain can be seen in figures 1 and 2. The found species have been ranked in ecological groups. The classification has been performed on the basis of Lozek's work (1964). Merging the 10 groups used by Lozek, we have distinguished 5 groups of species: forest species, steppe species, mezophyle species, higrophyle species and aquatic species.

In figure 1 the found species are indicated by a continuous line under the biotope.

A high number of forest species has been identified in the willow-grove on the bank and in the furze-field, but two species have been also found in the grasslands.

The forest-species of the willow grove and those of the furze-field are completely different: in the willow-grove on the bank we have found euribionte species, well adapted to the changes of the environment: *Bradybaena fruticum, Helix pomatia, Perforatella vicina*. These species have been found in the course of our research that encompassed the whole river-valley, in almost every sampling-point), whereas in the furze-field the found species are typically forest type, which live in areas with a humid, cool climate and a closed vegetation (*Cochlodina marisi, Euomphalia strigella, Laciniaria plicata, Perforatella bidentata, Ruthenica filograna*).

The steppe-species can be found in the furze-field and in the grasslands in increased number. *Cepea vindobonensis* is an euribionte species, similar to the above-mentioned ones. The abundant presence of the steppe species in the furze-field indicates the openness of the domain. The presence of *Pupilla muscorum* only in the hay-fields shows that these areas are much drier than the furze-field.

The mezophyle species can be found mainly in the willow-grove on the bank.We have found reference in the literature to the fact that in the forest the proportion of the mezophyle species is greater than in open areas (Domokos).

The higrophyle species are present in all of the studied biotopes, but they are the most numerous in the grove on the bank, because this is right beside the water. Among the higrophyle species *Succinea oblonga* and *Zenobiella rubiginosa* are also species with a good adaptability, and have been found throughout the whole river valley.

The sole aquatic species (*Lymnea stagnalis*) was found in the furze-field, but the sub-fossile character of the empty shell hints to the fact that it had been carried there by former floods.

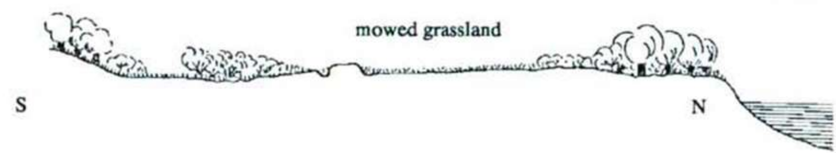
The band-diagrams in figure 2. illustrate the percentage of the species-groups in the four biotopes. It indicates that in the willow grove the forest species, the mezophyle and the higrophyle species are present in a nearly equal proportion. The forest-species demonstrate the presence of woody vegetation, the mezophyle species prove the closeness of the vegetation, and the higrophyle species indicate the proximity of water and the humidity of the air. In the grasslands the steppe species predominate, but the mezophyle, higrophyle and forest-species are also present, in a lower extent. This fact proves the migration of the species. In the furze-field the proportion of the forest-species is similar to that of the steppe one, because the area is bushy, but it is characterised by open vegetation and the presence of the higrophyle species indicates the humidity of the area.

To demonstrate the differences in diversity between the biotopes, we drew the species-number-log.abundance graph (fig. 3.), where every biotope is indicated by a line. The steepness of the lines indicates the uniformity of the distribution, i.e. the steeper the line is, the greater is the difference between the numbers of the species within a biotope.

The uniformity of the willow-grove and that of the furze-field are similar and so is the steepness of the two lines of the grassland but in the cultivated lands there are less species and the steepness of the lines indicates the great difference in the number of the species. The diversity of the grassland is smaller than that of the more natural areas.The diversity of the hay-field is the smallest.

**Mureş floodplain**

The road between Sălciua and Pojoga




*Forest sp.*

Bradybaena fruticum
Cochlodina laminata
Cochlodina marisi
Euomphalia strigella
Helix pomatia
Laciniaria plicata
Perforatella bidentata
Perforatella vicina
Ruthenica filograna

*Steppe sp.*

Cepaea vindobonensis
Granaria frumentum
Helicella obvia
Monacha cartusiana
Pupilla muscorum
Vallonia pulchella
Vertigo pygmaea

*Mezophyle sp.*

Cochlicopa lubrica
Punctum pygmaeum
Vitrea crystallina

*Higrophyle sp.*

Oxyloma elegans
Succinea oblonga
Succinea putris
Zenobiella rubiginosa

*Aquatic sp.*

Lymnaea sp.

**Fig. 1. The 300 m long N-S oriented malacofaunistical transect on the Mureş/Maros floodplain (07-12.08.2001)**

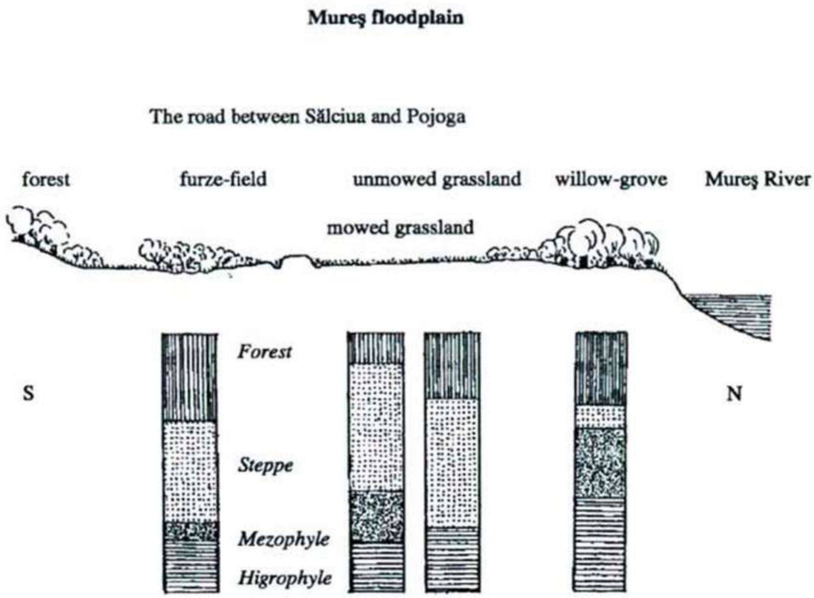



Fig. 2. Band diagrams of the Lozek's species groups on the Mureş/Maros floodplain based on the transect (07-12.08.2001)

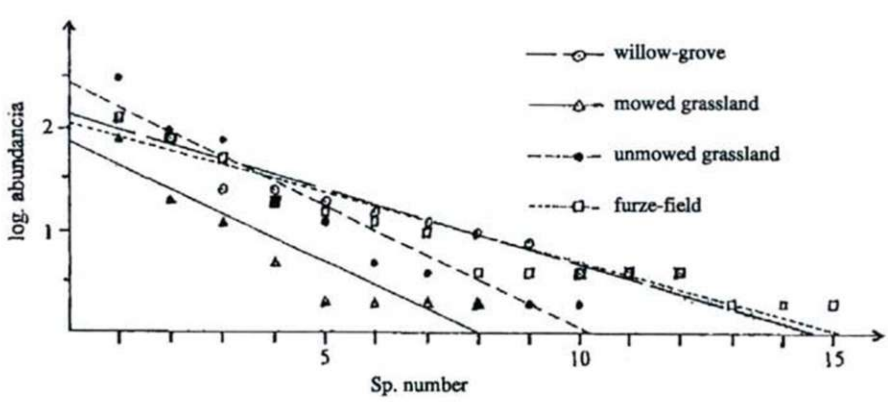



Fig. 3. Species number - log abundance graph.

## Conclusions

In the course of the data analysis we have come to the conclusion that there are two fluctuation zones along the transect, on both sides of the road connecting the grasslands and the furze-field. Because the forest-species of the willow-grove and those of the furze-field are different, the species found in the willow-grove must have been carried into this biotope by the river, by the way of hydrochor expansion. As we have already mentioned, these species have been found in many places along the whole river. The forest-species of the furze-field must have come from the neighbouring forest on the mountain slope.

In the course of our research the hypothesis that the malacofauna clearly indicates the microclimate of the area has proven to be true, despite the fact that the species' migration tends to merge the differences existing between the biotopes, because the species in exhibiting a pronounced ecological resistance are present in most of the biotopes.

Due to human activity, the diminution of the diversity of the malacofauna becomes manifest. The diversity of the willow-grove and that of the furze-field (which is no longer cultivated) are bigger than that of the hay-fields.

## Further tasks

Our results point to the necessity of further research and determine its line:

– to examine in detail the fragmenting effect of the road; to take samples from the grasslands and the furze-field in those places that are close to the road. By comparing these results with each other, we can get an answer to the questions concerning the effect of the road on migration.

– to investigate in detail if the fluctuation present in some biotopes comes or not from the area that we suppose ; we should examine the alluvial deposits on the banks of the Mureş rive and we should expand the transect to the forest situated on the mountain slope.

– to take samples from the right bank of the river along a similar transect and to compare the results with the above-mentioned ones; on this basis we could deduce the presence and effects of the hydrochor expansion and of the migration through the flood-plain.

We owe thanks to dr. László Gallé, the head of the Department of Ecology at the Szeged University, for his material support given to our field-activity and to dr. Katalin Margóczi for the botanical data.

We thank to the Management of the Museums in County Békés for their support and for the bibliographical data.

## References

Deli, T. (1997): A Praecarpathicum fejlődése az Alföldön a terrestris Molluscafauna boigeográfiai és paleogeográfiai elemzése alapján – Szakdolgozat, Szarvas.

Domokos, T. – Varga, A. (1994): Az uszadékokról, különös tekintettel a Drávából származó uszadék molluszka tartalmának vizsgálatáról – Malakológiai Tájékoztató, Gyöngyös; Vol. 13: pp.67-79.

Grossu, A. V. (1981, 1983, 1987): Gasrtropoda Romaniae – Vol. II., III., IV., Bucureşti.

Kerney, M. P. – Cameron, R. A. D. – Jungbluth, J. H. (1983): Die Landschnekcken Nord- und Mitteleuropas, Hamburg und Berlin.

Ložek, V. (1964): Qartärmollusken der Tschechoslowakei, Rozpravy Ú. Geol. 31.

Pelbárt, J. (2000): Magyarország recens Mollusca faunájának tudományos névszótára, Nagykovácsi

Répási, J.-né (2000): Összehasonlító malakológiai vizsgálatok a Feketek-Kőrös magyarországi szakaszának ártéri ligeterdeiben – Szakdolgozat, Szeged.

Újvári, I. (1972): Geografia apelor României, Bucureşti, pp.299-337.

ANDREI SÁRKÁNY-KISS, KLÁRA VÁNCSA
"Babeş-Bolyai" University, Faculty of Biology and Geography,
Dept. of Ecology and Genetics,
5-7 Clinicilor St., RO 3400 Cluj-Napoca,
asarkany@hasdeu.ubbcluj.ro

TAMÁS DOMOKOS
Munkácsy Mihály Museum
6. Széchenyi
5600 Békéscsaba, HU

# ENDANGERED FRESHWATER MOLLUSC SPECIES FROM THE EASTERN TRIBUTARIES OF THE TISA RIVER (ROMANIAN TERRITORY)

*Ioan Sîrbu and Andrei Sárkány-Kiss*

## Abstract

Based on long-term research this paper aims to reveal the status of 10 highly endangered freshwater mollusc species from the eastern Tisa River Basin. In all cases the adverse human pressure (pollution, hydrotechnical works and drastic reduction of wetlands) is responsible for the present-day status of this fauna, several species having a highly patchy distribution, some became rare or even extinct. Despite these facts some trends of recovery are also registered on the main rivers in Transylvania.

**Keywords:** human impact, biodiversity, pollution ecology, malacology

## Introduction

The freshwater molluscs are relatively easy to be used in a biomonitoring system, because they respond in a short time, and a very specific manner, to the changes in the environmental conditions. This synthesis refers to the most endangered mollusc species from the eastern tributaries' hydrographical basins of the Tisa River (Romanian territory). Its aim is also to draw attention upon some species that need special protection in the near future. Because of the long history (almost two centuries) of malacological research in Transylvania, it is possible today to trace the changes regarding the mollusc fauna that have occurred both in time and space. We consider in this paper those species that were once wide spread (according to the references), but became, because of human pressure (mainly pollution, habitat degradation, hydrotechnical works, desiccation of wetlands etc.) very rare (living in a very few habitats), surviving through small-sized, highly patchy, scattered populations. The fact that a species is rare (i.e. seldom quoted) is not an enough criteria to consider a species as endangered, because (as it happens with most clams, spring-snails and cave-snails from Romania) their rarity is sometimes linked to subjective causes (lack of information from the past, insufficient present-day research etc.).

The first more comprehensive list of autochthonous mollusc species was published in 1843 by Michael Bielz, and was followed by a catalogue published in 1851. Among the naturalists from the Transylvanian Society for Natural Sciences in Sibiu, which was founded in the middle of the past century, we highlight Albert E. Bielz, as one of the most remarkable malacologists of that time. He published the first monography regarding the malacofauna from this territory in 1862. Another great malacologist was Mauritius von Kimakowicz, from the same society in Sibiu, but he was focused mainly on terrestrial snails, and less on freshwater species, having in this respect only a few contributions (e.g. his paper published in 1885). Other contributions to the knowledge of the freshwater mollusc fauna from the tributaries of the Tisa River were provided by C.A. Westerlund (1886), S. Clessin (1887), C.F. Jikeli (1878), M. Rotarides (1930), L. Soós (1942) and by A.V. Grossu (1941, 1962, 1986, 1987, 1993). Most of these authors have quoted the species and the sampling points, as A.E. Bielz mentioned them, without verifying if the species still live in the specified habitats and places. The mollusc fauna from Banat is better known through the works of A.V. Grossu (1942, 1976 and others) and researches accomplished along the main rivers in the past years.

## Research background

A. Sárkány-Kiss performed an intensive research activity on the Mureş River, beginning with 1969 in some areas, and later, in 1978 and 1989 he extended the investigations on the whole river. In the frame of several Romanian-Hungarian multidisciplinary projects, organised by Liga Pro Europa, Târgu Mureş and Tisza Klub, Szolnok with the participation from different universities and institutes of both countries, further investigations of the freshwater mollusc fauna were made, as it follows: 1991 Mureş, 1992 Someş, 1993 Mureş - the middle part and Târnava Mică, 1994 Crişul Alb and Crişul Negru, 1995 - Crişul Repede, Barcău and Tisa, 1996 - Someş and Lăpuş Rivers. Both authors of this paper have worked together in the Someş, Olt and Mureş rivers basins (1996 - 2000), and separately in the rivers from Maramureş (1999 - 2001), namely Iza, Mara, Vişeu and Vaser rivers. They investigated also the wetlands from the Transylvanian Plain, during another research project. I. Sîrbu has completed the knowledge regarding the freshwater molluscs by several field-investigations in Banat. In 1998 the Nera, Caraş and Danube rivers were researched, followed in 2000 by Bega, Timiş and Cerna rivers and other wetlands from this region, in 2002 (together with Monica Sîrbu) the Danube sector from Banat, once again Cerna, Timiş and Bega Rivers, and also the lowland sectors of the Criş rivers. Besides, after 1996 I. Sîrbu gathered data on the specified group from glacial lakes (Retezat, Făgăraş and Rodnei Mountains), from different other wetlands and rivers (like the Ier River, wetlands in the Criş Rivers Basin, Râul Negru, tributaries from the Olt and Mureş rivers basin, and others). In this paper we consider also some rivers that do not flow into the Tisa, like the Olt River and some rivers from the southern Banat, in order to obtain a sounder image of the present-day status of the endangered species. Besides this, some rivers, like Bega and Timiş, which were originally ascribed to different basins, are connected through channels, leading to the possibility of fauna exchange.

The sampling points have been selected in order to cover the whole area, to find and evaluate the effects of the human impact sources, and to identify the zones that still shelter a high diversity or some rare species. The adverse human impact was followed both in space and time, the latter by comparing the present-day diversity and chorology with all the available data from references.

## Results and discussion

In the area that could be ascribed to Transylvania, the Criş Rivers basin (Crişana), Maramureş and Banat 74 species of freshwater molluscs have been found until now (according to I. Sîrbu 2001; 51 species of gastropods and 23 of bivalves), and for the first time dispersal maps have been plotted for these areas, namely for the Unionidae (A. Sárkány-Kiss and I. Sîrbu, 2001), for clams and prosobranchs (I. Sîrbu, unpubl. data). The present-day status of the freshwater mollusc fauna proves the great habitat changes of the last decades, mainly caused by pollution of large river sectors, by hydrotechnical works and the drastic reduction of wetland areas.

Among gastropods, the prosobranch snails group the most exacting species of this Class. The genus *Theodoxus* comprised 3 species in the Romanian Eastern tributaries of the Tisa River, namely: *Theodoxus transversalis* C. Pfeiffer, 1828, *T. danubialis* C. Pfeiffer, 1828 and *T. prevostianus* C. Pfeiffer, 1828. All these are exacting, rheophylous, mostly lithophyllous elements, with high oxygen demands. Some authors are quoting also *T. fluviatilis* Linnaeus, 1758 but in the Tisa River basin from Romanian territory this species was not ever found, and it is a matter of future to establish its status on the Hungarian territory. Although it was several times quoted by different authors (in Tisa, Criş Rivers, Mureş River), it is almost surely mistaken with other congeners, at least in the last two cases. *T. transversalis* had in the past the most extensive range in the Tisa Basin among the species belonging to this genus. E. A. Bielz (1867) quoted it in several localities from the Mureş and Someş Rivers and their tributaries and also from the Olt River (mostly in the middle sectors of these rivers). L. Soós (1943), K. Bába (1958), A. Grossu (1974, 1966) still found this species in several localities from the specified area in the middle of the XXth century. The investigations accomplished in the past 20 years have shown the disappearance of this species from the whole length of the Olt, Mureş and Someş rivers, their tributaries, and from all quoted localities in Transylvania. Besides, it was not found in the Criş Rivers basin and in Maramureş region, being a matter of question if it still lives in the southern Banat, in the Danube and some of its tributaries that did not belong to the Tisa Basin. *Theodoxus prevostianus* is a termophylous relict species with a highly patchy distribution in Central and Eastern Europe. In the Danube basin it lives in some scattered sites, like Bad Vöslau and Bad Fischau (Austria), several places in Hungary (Soós, 1943; Richnovsyki and Pintér, 1979), and one certain place in Romania, at Răbăgani (Bihor county; Crişul Negru River Basin). In the last place it still lives only in a short sector of a rivulet, with mesothermal water. This rivulet is used by the inhabitants as cleaning source for the laundry and carpets and the source is also captured in a swimming pool, all these making it a highly endangered habitat. It is also to be noticed that *T. prevostianus* appears together with a melanic form of *Esperiana acicularis* (Férussac, 1823) syn. *Fagotia (Microcolpia) daudebartii acicularis* (as it happens in Austria as well), and some other more exacting species. The latter species appears here in the single point from the Romanian Criş Rivers basin. Some papers pointed out the presence of *T. prevostianus* also in other sites from Romania, like the flowing mouths of the Danube branches in the Black Sea, some few places in the Danube Delta, and another very important site, namely the Peţea lake (Băile Episcopeşti, hun. Püspökfürdő). The material I. Sîrbu has verified in the collections of "Grigore Antipa" Natural History Museum proved that the individuals sampled from the Danube Delta and ascribed to *T. prevostianus* are most likely melanian forms of *T. danubialis*. In the last case, several papers written by different authors ascribed the neritids found in Peţea Lake some to *T. prevostianus*, to *T. transversalis*, *T. danubialis* or - even - to some other species. In fact the species died out in this water a long time ago, it appears only as subfossil shells, that can be ascribed to *T. danubialis*, as it was correctly done by M. Paucă (1936) and later by A. Grossu (1986, as the form *serratilinea*). L. Soós raised another problem, by quoting *T. prevostianus* from the Secu rivulet, in the Călimani Mountains (one individual sampled by E. Gyula), although he recognised the possibility of an error. The authors of this paper have searched two times, independently, the cited region without finding the species. All this information draws to the conclusion that Răbăgani is the single point in Romania where *T. prevostianus* surely still lives, and because of the misusing of the water source, it should be included in the Red List as a highly endangered species. *T. danubialis* was not ever found in the Transylvanian tributaries or in the Romanian Criş Rivers Basin. It lived in northern Banat, in Bega channel near Timişoara (A. Grossu, 1941) but is in present probably extinct in the Tisa tributaries from this region (I. Sîrbu, unpubl. data). It still lives in the southern part of Banat, in the rivers that flow into the Danube (Nera, Caraş), and is absent from the Timiş and Bârzava rivers (I. Sîrbu and Monica Sîrbu, 1998). The problematic status of *T. fluviatilis* in the Tisa area has to be solved in the future.

Regarding the Peţea thermal lake (near the town of Oradea) another problem has to be raised. In this water lives an endemism, namely *Melanopsis parreyssi* Philippi, 1847. Originally this pliocenic relict survived only in this place, but it was artificially carried in several other places and countries (like Hungary and Germany). In Peţea Lake there still lives an endemic fish subspecies and a variety of *Nymphaea lotus (var. termalis)*. This site should be, and legally or formally it surely is, strictly protected. As it was revealed in a field trip, that is not the case (I. Sîrbu, 2001). For instance, the guardian is either not present or too tolerant with the intruders, inhabitants are using the water in different purposes, scientists from the whole Europe sample material, too many researches and researchers working in the lake, too much interest etc. Because it was obvious that alien plants brought by aquarists are in full expansion, non-governmental organisations carried out cleaning actions by cutting and uproot the invasive species using large amounts of volunteers, that disturb the habitat. These sites, and species, are endangered because of too much "scientific" interest and lack of sound legal protection.

Another endangered prosobranch gastropod is *Valvata cristata* O.F. Müller, 1774. The authors of the present paper checked out all the Transylvanian quoted sampling points from the past. E.A. Bielz (1867) found the species in several sites from Braşov, Sibiu and Mureş counties (middle Olt River Basin and Târnava Basin), L. Soós (1943) quoted the species from the middle Someş Basin (Cluj-Napoca county), Mureş River Basin (Alba county), A. V. Grossu (1974) sampled it from several lakes and ponds from northern Banat. In the past 20 years this species was not ever found in Transylvania, and the presence in Banat is doubtful.

Shrinking habitats, reduced ranges and patchy distribution are common patterns also for other prosobranch snails. It is hard to say if the threat is greater in stagnant ecosystems than in lotic environment. The most obvious examples in the former category are *Viviparus contectus* Millet, 1813, *Valvata pulchella* Studer, 1820, *Valvata naticina* Menke, 1845, *Bithynia leachi* Sheppard, 1823 and in the latter is *Lithoglyphus naticoides* C. Pfeiffer, 1828. The last species has almost totally disappeared from Transylvania, but it still lives in high numbers in Criş Rivers, Bega, Timiş, and the southern rivers from Banat and in the Danube.

Habitats' destruction affects also some more exacting basommatophoran pulmonates in the same way. *Anisus rotundatus* Poiret, 1801 was quoted once in Transylvania, near Braşov (E. A. Bielz collection XIXth century, in "Grigore Antipa" Natural History Museum in Bucharest) and found in very few sites in Banat, in swamps near Timişoara town (A.V. Grossu, 1941) and in the Danube valley. It was not recovered again. *Anisus vorticulus* Troschel, 1852 was quoted near Timişoara (A.V. Grossu, 1941), in southern Banat (1972, 1974), and it still lives in some small-sized, scattered wetlands from the middle Olt River Basin (I. Sîrbu et al., 1999), and near the Ier River at Răduleşti (Criş Rivers Basin; I. Sîrbu, 2001). *Bathyomphalus contortus* Linnaeus, 1758 was once widely spread in ponds and other stagnant wetlands, with rich vegetation, in the middle basins of the Olt and Mureş rivers (E. A. Bielz, 1867, M. Kimakowicz, 1883). As it happened in other cases further papers have quoted this old records without verifying if the species still lives in that sites. In Transylvania there are only a very few sure records from the XXth century, namely at Răstoliţa (Mureş River Basin), a single individual sampled once in a pond with vegetation (A. Sárkány-Kiss, 1989), and two sites (a marsh and a dead branch) in the middle Olt River Basin (I. Sîrbu et al., 1999). The same pattern is valid also for *Armiger crista* (Linnaeus, 1758). Often sampled in the XIXth century, it became very rare in the past decades in Transylvania. In the last years it was quoted once at Ungheni in some ponds that were soon after desiccated (A. Sárkány-Kiss, 1989). It still lives in two wetlands in the Cibin River Basin (tributary of the Olt River) in Sibiu and Şelimbăr (I. Sîrbu and A. Curtean-Bănăduc, 2002). It was quoted in Banat, near Timişoara (Bega River), in Aranca River, several ponds in northern Banat, and Criş Rivers Basin (A.V. Grossu, 1941; L. Soós, 1943).

The most often encountered mollusc association in the Transylvanian reaches of the major rivers, is formed today by some few highly eurybiotic basommatophoran snails. The prosobranchs usually inhabit stable and larger habitats, being far less tolerant to environmental fluctuations than the basommatophoran pulmonate gastropods. The species from the last group tend to have a worldwide distribution and to be ubiquitous, a lot of them being highly eurybiotic species inhabiting a broad range of habitats (R. MacMahon, 1983). When the life conditions are going down there is a switch from prosobranch-basommatophoran communities to pulmonate eurybiotic species domination.

The bivalves (naiads and clams) show different patterns as answers to degraded and/or polluted environment. The Unionidae need more stable and larger habitats with a certain quality of the abiotic factors, while the pisiids tend to group more tolerant, some even ubiquitous and eurybiotic, species, capable to inhabit all kind of habitats, from glacial lakes and springs to lowland temporary pools or - on the other side - great deltas and estuaries. The apparent rarity of some clams in the area of reference is mostly idle. Almost all species that were rarely found in the past are considered today much more frequent than it was assumed, because of better coverage of the field investigations and better research plans. Most old references concerning the Unionidae from the eastern tributaries of the Tisa River are out of date, because long sectors of all rivers were exposed to a severe human impact. The Unionidae and some freshwater prosobranch gastropods are more sensitive to pollution than most other systematic groups inhabiting the middle and lower rivers' sectors. When the mussels disappear, it means a serious damage of the self-supporting and self-cleaning capacities of the rivers and the debasement of life-condition and community fitness. A synthesis regarding the Unionidae from the Transylvanian tributaries of the Tisa River was published by A. Sárkány-Kiss (1997) and the first UTM distribution maps, highlighting the past and present-day distribution of these species were plotted last year (A. Sárkány-Kiss and I. Sîrbu, 2001). It was pointed out that in all cases, the communities were forced to reduce their range and richness. Anyhow, in the past 10 years a trend of recovery was also noticed.

The temporal and spatial molluscs communities' dynamics from the Mureş River can be used as a case study. Until the 80's some Unionidae populated the whole river length (except the source region and one short hydro-geo-chemical barrier in the Gheorgheni Depression). In the upper river's basin *Unio crassus* Philipsson, 1788 and *Anodonta anatina* Linnaeus, 1758 were the dominant benthic species. In the middle and lower course there prevailed *Unio pictorum* Linnaeus, 1758, *Unio tumidus* Philipsson, 1788, *Anodonta cygnaea* Linnaeus, 1758 and - in a lesser extent - *Pseudanodonta complanata* Rossmässler, 1835. During the expedition in 1991 not a single individual was found downstream the point where the Târnava River flows into the Mureş. The heavy metals originated from Copşa Mică and discharged by this tributary represented the limiting factor that made the environment unsuitable for this species and a lot of other systematic groups. This caused the extinction of *Pseudanodonta complanata*, species that inhabited the river's middle and lower course. Downstream the confluence there were registered high concentrations of Cd (2 mg/l), Zn (147 mg/l), Pb (30 mg/l), Cr (75 mg/l) in the water and also high contents in sediments (Waijandt, 1995). This point was also the threshold for several other mollusc species mainly prosobranch gastropods. In the same period the debasement of Unionidae communities was also registered downstream the town of Tg. Mureş to the confluence with Târnava River, mainly because of wastewater discharges. The absence of Unionidae was considered a major proof of human impact on the river's ecological state. In the years 1999 and 2000 the authors have found a new spatial dynamics of the Unionidae species. In the upper course *U. crassus* is still present with low densities, and - downstream Tg. Mureş, several other species like *A. cygnaea, A. anatina* and *U. pictorum*. These Unionidae have today a patchy distribution, in a spatial aggregate dispersal, both because of the availability of specific habitats and of the pollution and ballast excavations. In 2000 there were found Unionidae downstream the point where the Târnava River flows into Mureş. At Sântimbru and Vinţu de Jos, some few scattered individuals of *Unio pictorum* and *Anodonta cygnaea* have been found near the river-banks, proving a significant increase in both water and sediment quality. In the river's lower course one single individual of *A. cygnaea* was sampled near the town of Arad (leg. Doru Bănăduc), and it is highly probable that in the future the populations will regain some of their past range if the conditions are going to improve further.

Regarding the Unionidae communities, however, shrinking ranges and patchy distributions are still the most characteristic trends. The most threatened species is *Pseudanodonta complanata*, which has disappeared from the main part of the investigated area. It was quoted by E.A. Bielz (1853) in dead-branches in the Turnu-Roşu Gorges (Olt River) that have disappeared in time. It is considered extinct in Transylvania (in both Someş and Mureş basins), it is still present in the Criş Rivers Basin (A. Sárkány-Kiss et al., 1997), in the Tur River at the dam lake from Călineşti-Oaş (A. Sárkány-Kiss and I. Sîrbu, 1998), and in some rivers of the northern Banat, some belonging to the Tisa River Basin and some tributaries of the Danube (A. Grossu, 1941; P. Bănărescu and I. Sîrbu, 2002). Among the clams, the single seriously endangered species is *Sphaerium riviculum* (Lamarck, 1818). It is not known from the Someş and Olt rivers basins, and is extinct in the Mureş River (last quoted at Gălăuţaş, Subcetate; A. Sárkány-Kiss, 1989). In the Criş rivers basin it is still present in some few, scattered areas (A. Sárkány-Kiss et al., 1997) and the same is valid for Banat (I. Sîrbu, unpubl. data).

## Conclusions

The poor mollusc fauna, indicating degraded environmental quality, was registered in the riverbeds of some sectors of the main rivers from Transylvania (especially in the upper course of the Olt River, the middle and lower courses of the Mureş and Someş rivers). The best ecological state was encountered in Banat, and also in the springs, rivulets and glacial lakes from the Carpathian Mountains. Despite the human impact, some scattered, small-sized wetlands have preserved their natural status, sheltering remnant mollusc communities that should be protected and that can serve in the future as natural sources for repopulation.

The present-day status of the freshwater mollusc fauna proves the great changes that have occurred in the past time, regarding the specific habitats and the quality of the freshwaters, in comparison with the situation registered by the malacologists from the XIXth and the middle of the XXth Century. It is definite that the pollution and the hydrotechnical works, during the last 40 years, determine these changes. The aquatic molluscs have responded to environmental changes in several forms. Many species have a patchy distribution; some became rare or have disappeared from the main part of their former range. In these areas, the main trend is the prevailing of some eurybiotic basommatophoran pulmonates in correlation with the debasement of most prosobranch snails and of the Unionidae assemblages. However, in the past 10 years we have encountered a trend of recovery, because of pollution reduction.

Some species, namely *Theodoxus transversalis* C. Pfeiffer, 1828, *T. prevostianus* C. Pfeiffer, 1828, *Valvata cristata* O.F. Müller, 1774, *Melanopsis parreyssi* Philippi, 1847, *Anisus rotundatus* Poiret, 1801, *A. vorticulus* Troschel, 1852, *Bathyomphalus contortus* Linnaeus, 1758, *Armiger crista* (Linnaeus, 1758), *Pseudanodonta complanata* Rossmässler, 1835 and *Sphaerium riviculum* (Lamarck, 1818), are highly endangered, and need special attention and protection in the future.

## References


Bănărescu, P.M., Sîrbu, I., 2002 - Contribution to the knowledge of the Banat aquatic fauna. In Studies in Biodiversity - West Romania Protected Areas, Timişoara, May 9-10: 108 - 115.

Bába, K., 1958 - Die Mollusken des Inundationsraumes der Maros. Acta Universitatis Szegediensis; Acta Biologica, Nova Series, **IV** (1-2): 67 - 71.

Bielz, A.E., 1867, Fauna der Land- und Süsswasser-Mollusken Siebenbürgens. Zweite Aufl., Comissions-Verlag v. Filtsch, Hermannstadt.

Bielz, M., 1843 – Aufzählungen der Siebenbürgischen Land- und Süsswasser-Mollusken. Kronstädter Zeitung.

Bielz, M., 1851 – Verzeichniss der Land- und Süsswasser-Mollusken Siebenbürgens. Verh. Mitt. Siebenb. Nat., Hermannstadt, **2**, 17 – 19.

Grossu, Al.V., 1942 – Die Gastropodenfauna der Umgebung von Timişoara. C. r. Séanc. Acad. Sci. Roum. 6 (1-4), 183 – 187.

Grossu, Al.V., 1974 – Caracteristica şi asociaţiile de gasteropode din Banat în diferite ecosisteme. "Tibiscus" – Centenar Muzeul Bănăţean Timişoara, 95 – 106.

Grossu, Al. V., 1962 - Mollusca; Bivalvia. Fauna R.S.R., **3**, 3, Edit. Acad. Bucuresti.

Grossu, Al.V., 1986 - Gastropoda Romaniae, **1**; I. Caracterele generale, istoricul şi biologia gastropodelor; II. Subclasa Prosobranchia şi Opistobranchia. Ed. Litera, Bucureşti.

Grossu, Al.V., 1987 - Gastropoda Romaniae, **2**; Subclasa Pulmonata, I. Ordo Basommatophora, II. Ordo Stylommatophora (Suprafamiliile Succinacea, Cochlicopacea, Pupillacea), Ed. Litera, Bucureşti.

Grossu, Al. V., 1993, The catalogue of the molluscs from Romania. Trav. Mus. Hist. nat. "Grigore Antipa", **33,** Bucureşti: 291 - 366.

Kimakowicz, M.v., 1884-1885 – Beitrag zur Molluskenfauna Siebenbürgens. Verh. Mitt. Siebenb. Ver. Naturw., Hermannstadt, **33:** 13 – 83, **34**: 57 – 117.

McMahon, R.F., 1983 - Physiological Ecology of Freshwater Pulmonates. The Mollusca, Ecology. Russel-Hunter, W.D., eds., Academic Press, Inc. Orlando, San Diego, San Francisco, New York, London, Toronto, Montreal, Sydney, Tokyo, Sao Paulo, **6**: 360-431.

Paucă, M., 1936 - Les Mollusques pléistocenes de Băile Episcopeşti. Bul. Soc. Rom. Geol., **3**: 130 - 142.

Richnovszky, A., Pintèr, L., 1979, A vizicsigák ès Kagylók (Mollusca) Kishatározója. Vizügyi Hidrobiológia, **6**, Budapest

Sárkány, E., 1977- Előzetes tanulmány a Maros folyó Unionidae kagylópopulációira vonatkozóan. Aluta, Muz. Sf. Gheorghe: 273-287.

Sárkány-Kiss, A., 1983 a Contribuţii la cunoaşterea populaţiilor şi asociaţiilor de gastropode acvatice din valea rîului Mureş, sectorul Izvorul Mureşului - Tg.Mureş. Marisia, Stud.scient.nat., **11-12**: 105-113.

Sárkány-Kiss A., 1983 b - Note preliminare la cunoaşterea faunei de moluşte dulcicole a văii Mureşului între Tîrgu Mureş şi Arad. Marisia, Stud. scient. nat. **11-12**: 121-123.

Sárkány-Kiss, A., 1995 - Malacological survey on the Mureş (Maros) River. In The Maros/ Mureş River Valley. Tiscia monograph series, Hamar (J.) & Sárkány - Kiss (A.) edit., Szolnok - Szeged - Târgu Mureş: 193 - 201.

Sárkány-Kiss, A., 1997 - The present-day situation of the Unionidae (Mollusca, Bivalvia) in the transylvanian tributaries of the Tisa River (Romania). Trav. Mus. Hist. natl. "Grigore Antipa", **37**: 213 -224.

Sárkány-Kiss, A., Boloş, F., Nagy, E., 1997 - Freshwater molluscs from the Criş/Körös rivers. The Criş/Körös Rivers Valleys, Tiscia - Monograph series, Szolnok - Szeged - Tg.Mureş: 195 - 202.

Sárkány-Kiss, A., Sîrbu, I., Bába, K., 1999 - Freshwater mollusc species from the River Someş/Szamos, related to their ecological conditions. The Someş/Szamos River Valley, Tiscia - Monograph series, Szolnok - Szeged - Tg.Mureş: 197-202.

Sárkány-Kiss, A., Sîrbu, I., 2001 - Mapping the Unionidae from the eastern tributaries of the Tisa River; past and present-day status. World Congress of Malacology 2001 - Vienna, Austria (Abstract): 306.

Sárkány-Kiss, A., Sîrbu, I., 1999 - Aspects concerning the structure and the biometry of some freshwater mollusc communities from the Tur River (Romania). Acta oecologica, Univ."Lucian Blaga" Sibiu, **6** (1-2), p. 45 - 57.

Sîrbu, I., Sîrbu Monica, 1998 - Date actuale privind asociaţiile de prosobranchiate acvatice (Mollusca: Gastropoda) şi de Unionidae (Mollusca: Bivalvia) din râurile Nera şi Caraş. Acta oecologica, Univ. "Lucian Blaga" Sibiu, **5 (1-2)**: 26 - 44.

Sîrbu, I., Sárkány-Kiss, A., Petrescu, M., Lazăr, Bianca, Buian, G., 1999 - Contributions to the knowledge of the freshwater mollusc fauna from the upper and middle Olt River Basin (Romania). Transylvanian Review of Systematical and Ecological Research, Sibiu, 1: 111 - 122.

Sîrbu, I., 2001 - Human impact effects on the freshwater mollusc fauna from Transylvania and Banat (Romania). World Congress of Malacology 2001 - Vienna, Austria (Abstract): 329.

Sîrbu, I., 2001 - The freshwater molluscs from the Ier River, the thermal lake from Băile Episcopeşti and Răbăgani (Criş Rivers Basin). Acta oecologica, Univ."Lucian Blaga" Sibiu, VII (1-2): 93 - 106.

Sîrbu, I., 2002 - Freshwater molluscs from the Târnave Rivers Basin. Transylv. Rev. Syst. Ecol. Res., **2** (in press).

Soós, L., 1943 - A Kárpát-medence Molluska faunája. Magyar Tudományos Akadémia, Budapest.

IOAN SÎRBU
"Lucian Blaga" University, Faculty of Sciences,
Dept. of Ecology and Environmental Protection,
31 Oituz St., RO 2400 Sibiu,
sirbui@yahoo.com;

ANDREI SÁRKÁNY-KISS
"Babeş-Bolyai" University, Faculty of Biology and Geography,
Dept. of Ecology and Genetics,
5-7 Clinicilor St., RO 3400 Cluj-Napoca,
asarkany@hasdeu.ubbcluj.ro;

TISCIA monograph series (2002), 6, 81–92

# COMMUNITIES' STRUCTURE AND HEAVY METALS CONTENT OF THE UNIONIDAE (MOLLUSCA, BIVALVIA) FROM THE DANUBE DELTA BIOSPHERE RESERVE

*Andrei Sárkány-Kiss, Nicolae Mihăilescu, Ioan Sîrbu*

**Abstract**

This paper presents the Unionidae assemblages from some areas of the Danube Delta Biosphere Reserve. Among the 6 species of naiads, the most abundant is *Anodonta cygnaea* L. 1758, and the most rare is *Unio crassus* Philipsson, 1758. The adventive species *Anodonta woodiana* Lea, 1834 is in full process of expansion, being a potential danger for the autochthonous species. The contents of some heavy metals in water, sediments and bivalves (both in soft body and shells) are analysed. Although the mostly researched areas from the DDBR are in pristine ecological conditions, the hydrotechnical works and pollution represent serious dangers for the future. In many cases the most hazardous metals are above safety limits for these organisms.

**Keywords:** Danube Delta, Unionidae, heavy metals, communities

## Introduction

The Unionidae from the Danube Delta Biosphere Reserve are represented by 6 species, among them 5 are native (namely *Unio pictorum* L. 1758, *U. tumidus* Philipsson, 1788, *U. crassus* Philipsson, 1788, *Anodonta cygnaea* L. 1758 and *Pseudanodonta complanata* Rossmässler, 1835) and one (*Anodonta woodiana* Lea, 1834) is adventive. Once, another unionacean species was considered to be present in the DDBR and other areas of the Danube, namely *Colletopterum letourneuxi* Bourguignat 1881 (according to Grossu, 1962, p. 185, Fig. 94), but the authors of this paper agreed that it is an artificial species, being only a morph of *A. cygnaea.* Even Grossu reconsidered his position, e.g. he did not include this taxon in the catalogue of the molluscs from Romania published in 1993.

The naiads are excellent bioindicators of environmental state and quality, both defined by their populations and assemblages' parameters and by the capacity of bioaccumulation, especially of different xenobiotics. Unionaceans are associated with pristine conditions, i.e. unpolluted water, natural-like habitats, being thus a negative index of pollution. Among all bivalves these are the most affected ones by anthropogenic alteration of the waterways (Burky, 1986). Although the most part of the Danube Delta Biosphere Reserve shelters habitats in good condition, some parts were disturbed because of hydrotechnical works. Channelization straightens and deepens winding waterways, until they become virtual canals. This process is always correlated with density-decreased populations, dispersal alteration, and high mortality rates of juvenile stages. Damming, on the other hand, is associated with parasitism, alteration of oxygen and temperature regimes and siltation.

Heavy metals are among the most dangerous xenobiotics, being responsible in a high degree for the disappearance of unionaceans from some rivers reaches. The most toxic elements are, in descending order: Zn, Cu, Hg and Ag (Fuller, 1974). I. Sîrbu et al. (unpublished data) exposed individuals of *U crassus* to 1 ppm Cu, Ag, Pb, Ni, and Hg. It was pointed out that the respiration rate was reduced to less than 1/10 in the case of Cu and Ag, to 1/3 in the case of Hg, 1/2 in the case of Pb and Ni, compared with the control sample. It was also shown that the regression between oxygen uptake and Log (weight) was altered; especially in the samples exposed to Cu and Ag the highest rates of inhibition were recorded both in juvenile and old stages of life. Higher concentrations lead to the disappearance of unionids, as it happened on long reaches of the Someş, Lăpuş, Tur, Mureş and Bârzava rivers.

This study aims to highlight some characteristics of unionacean communities' structure and of their heavy metals contents in shells and soft body parts, both from the Danube River and Delta.

## Research methods

The Danube Delta Biosphere Reserve was intensely studied during a project of biodiversity inventory (1991-1999). During the field trips the freshwater molluscs were studied mainly in the strictly protected areas, but also in the buffer zones and surroundings. Unionids were sampled both manually and with dredges. Individuals were sampled from the Danube River and Delta, in order to analyse their heavy metals content.

## Results and discussion

As it is shown in Tab. 1, the most abundant species in the DDBR is *Anodonta cygnaea,* followed by *Unio pictorum* and - in less extent - by *Unio tumidus*. This pattern is common among lowland wetlands. *Unio crassus* is a rare species in DDBR, being constrained by the lack of specific habitats. It is also the single unionacean species included in the official Red List of the reserve (Sîrbu and Sárkány-Kiss, 2000, p. 80 - 81).

**Tab. 1. The structure of the Unionidae communities from different lakes and channels of the DDBR**

| | *Unio crassus* % | *Unio pictorum* % | *Unio tumidus* % | *Pseudanodonta complanata* % | *Anodonta cygnaea* % | *Anodonta woodiana* | Unionidae No.ind./m$^2$ | Unionidae less than 4-5 years - % | Unionidae less than 1 year - % | Recently dead individuals - % |
|---|---|---|---|---|---|---|---|---|---|---|
| Lake Merhei | | | 1,72 | 1,72 | 96,55 | | 1 | | | 40,00 |
| Lake Puiu | | 10,00 | | + | 90,00 | | 2,5 | | | |
| Lake Isacova | | 16,66 | | | 83,33 | | 3,5 | | | |
| Lake Roşu | | 14,81 | 24,69 | 1,23 | 59,25 | | 15 | 5,00 | | |
| Lake Matiţa | | 34,71 | 1,88 | | 43,39 | | 2,5 | 1,88 | | 30,00 |
| Lake Tătaru | | 60,71 | | 3,57 | 35,71 | | 2,8 | | | 30,00 |
| Lake Lungu | | 72,22 | | | 27,78 | | 3,6 | | | |
| Lake Uzlina | | 55,31 | 17,02 | | 27,65 | | 7 | 2,00 | | |
| Lake Fortuna | | 30,58 | 48,23 | 1,17 | 20,00 | | 8,5 | 4,70 | | |
| Lake Razelm | | 40,00 | 20,00 | | 60,00 | + | ? | 60 | 45 | |
| Lake Goloviţa | | + | + | | + | | ? | + | + | |
| Lake Zmeica | | + | + | + | + | | ? | + | + | |
| Lake Sinoie | | + | + | | + | | ? | + | + | |
| Lake Roşca | | 66,67 | | | 33,33 | | ? | 33,33 | 33,33 | 33,33 |
| Lake Belciug | | 13,04 | | 4,36 | 82,60 | | ? | + | | |
| Lake Rotundu | | 20,00 | | | 80,00 | | ? | 20,00 | | |
| Lake Babina | + | + | | | | + | | | | |
| Lake Lumina | | + | | | | | | | | |
| Lake Nebunu | | + | | + | + | + | | | | |
| Lake Sacalin | | + | + | + | + | + | | | | |
| Channel Dunavăţ | | 20,83 | 25,00 | 8,33 | 45,83 | | 12 | 20,00 | + | |
| Channel Lopatna | 20,00 | 60,00 | 20,00 | | | | 11 | 25,00 | + | |
| Channel Tătaru | | + | + | | + | | | | | |
| Ch. Caraorman | | + | + | + | | | | | | |
| Branch Chilia | | 33,33 | 66,66 | | | | ? | 50,00 | + | |

The most endangered species among native naiads seems to be *Pseudanodonta complanata*, which encounters low abundance in several areas, but it is widely spread inside the reserve. This species is endangered in most part of the country because of habitat destruction and pollution, while in the DDBR it is still currently sampled. Anyhow, siltation and xenobiotics are serious dangers for this exacting species, even in this reserve.

The adventive species *Anodonta woodiana*, first sampled 5 years ago, is in full process of expansion. In 1996 the species was recorded in the Balta Mare a Brăilei (a sector near the town of Brăila), and in the same year several empty shells from the Danube Delta were sampled (Marius Skolka pers. comm.). The first record of living individuals belonging to *A. woodiana*, was done in 1998 by Orieta Hulea, who had found the species in several pools and channels from the DDBR, namely in the Babina Lake, Cardon Lake south of Popina, and also in the areas of Nebunu, Alb, Meşter and Purcelu lakes. It is remarkable to find this species in the same year in several zones, considering the fact that the Danube Delta has been intensely researched, especially in the last 10 years. In 1999, I. Sîrbu had found one single dead individual in Meleaua Sacalin, south of the point where the Sfântu Gheorghe branch of the Danube flows into the Black Sea. In the shallow water of this place, the most dominant species is *Anodonta cygnaea*, followed by *Unio pictorum*. It is highly likely that *A. woodiana* will develop in the future a large and abundant population in the DDBR, as it does in other places soon after its appearance (Sárkány-Kiss, Sîrbu, Hulea, 2000).

Anyhow, sediments and alluvial accumulation, perturbation of waterflow and pollution are serious threats, fact that is proved by the small proportions of young mussels in most of the researched areas and by high values of recently dead individuals (see Tab. 1).

Regarding heavy metals and other elements content, the highest values are registered in the soft bodies for Ba, followed in descending order by Cu, Ni, Cr, Th, Co, Pb and Zn. In the shells the contents descend in the following order: Sr - Zn - Pb - Ni - Ba - Co - Cu - Cd. Analysing the rate between the contents in the soft body and shells, values higher than 1 are registered for Cu, having the maximums 33,35 in *U. pictorum*, 7 in *U. tumidus* and 6 in *A. cygnaea*, and also for Ba and Cr. In contrast, there are no significant values in the soft body for Zn and Pb, although the sediments are in some cases heavily loaded. Regarding the rate between the contents in the soft body and the upper layer of sediments, the highest values are registered in *U. pictorum* (51,15), and in a less extent in *A. cygnaea* (especially Cr, Co and Ni). *U. tumidus* seems to accumulate in the body less than the other analysed species. Regarding the ratio between shell contents and the upper thin layer of sediments, the highest values are shown by *A. cygnaea* (Co, Pb, Sr). *P. complanata* seems to accumulate especially Sr, Co, Pb, Zn, *U. tumidus* Sr and Co, *U. pictorum* Sr and Zn. It is obvious that in the same conditions different species tend to accumulate in different rates the existing heavy metals. Analysing the most hazardous metals for this species (Tables 2 - 5; Fig. 1 - 6), several patterns could be described. In all species the content of Cu in the soft bodies is higher than in shells. The contents in sediments and soft bodies are directly correlated up to a point, thereafter the rate is reversed.

**Table 2. Heavy metals contents in the water of the Danube Delta and Danube River (ppm).**

| *Sampling Site* | Layer | Cu | Pb | Zn | Ni | V | Cr | Co | Sr | Cd | Fe | As | Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roşu Lake | Top | * | * | * | 2.40 | .43 | * | * | 217 | .17 | 27 | * | .95 |
| | Bottom | * | * | * | * | .20 | * | .23 | 207 | .06 | 17 | 1 | * |
| Matiţa Lake | Top | * | * | * | .85 | 1 | * | * | 228 | .11 | 19 | * | 1.65 |
| | Bottom | 6 | 20 | * | 1.19 | .52 | 1 | .60 | 227 | .05 | 101 | 1.4 | .38 |
| Merhei Lake | Bottom | * | * | * | 2 | 1 | * | * | 232 | .06 | 6 | 1.4 | 1 |
| Fortuna Lake | Top | 2 | 760 | * | 2 | .46 | * | * | 200 | .08 | 22 | * | .08 |
| | Bottom | 2 | 5.30 | * | * | .71 | * | * | 200 | .10 | 14 | 1.2 | 1.6 |
| Meşteru Lake | Top | * | 45 | * | .42 | .99 | * | * | 222 | .18 | 23 | * | 1.5 |
| | Bottom | 1 | * | * | .70 | .92 | .03 | .42 | 196 | 2 | 161 | * | * |
| Danube km 866 | Bottom | * | 0 | * | 3 | 2 | .51 | 0 | 185 | .02 | 6 | 0 | 2 |
| Danube km 911 | Bottom | 2.30 | 4 | * | 3 | .86 | 1 | .02 | 163 | .03 | 104 | .9 | 1.8 |
| Danube km 950 | Top | 2.10 | 1 | * | 2.90 | .72 | 1.30 | .73 | 164 | 0 | 66 | 1.2 | .48 |
| | Bottom | 5.90 | 12 | * | 3 | 4 | .52 | .22 | 154 | .09 | 147 | 1.2 | 1.3 |
| Danube km 1044.6 | Top | .71 | 0 | * | 1.75 | .73 | .42 | .18 | 186 | 0 | 55 | 0 | .88 |
| | Bottom | 6.05 | .71 | * | 2 | .66 | .72 | .03 | 161 | .12 | * | 1.1 | 2.0 |

**Table 3. Heavy metals in the Danube's Delta and River sediments (ppm)**

| Sampling Site | layer | Cu | Pb | Zn | Ni | V | Ba | Cr | Co | Sr | Cd | Type of sediment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roşu Lake | A | * | 3 | 41 | 12 | 10 | 756 | 20 | 1 | 604 | 6 | Medium silt |
| Matiţa Lake | A | 10 | 10 | 19 | 19 | 48 | - | 46 | 5 | - | - | Coarse silt |
| | B | 7 | 9 | 15 | 15 | 48 | - | 47 | 6 | - | - | Coarse silt |
| Fortuna Lake | A | 50 | 22 | 83 | 47 | 118 | - | 104 | 15 | - | - | Fine silt |
| | B | 47 | 24 | 81 | 42 | 112 | - | 100 | 15 | - | - | Fine silt |
| Meşteru Lake | A | 180 | 24 | 149 | 37 | 100 | 1242 | 120 | 10 | 156 | 46 | Coarse clay |
| | B | 44 | 16.5 | 141 | 39 | 110 | 972 | 117 | 9 | 156 | 20 | Very fine silt |
| Danube km 866 | A | 897 | 67 | 0 | 98 | 118 | 960 | 168 | 21 | 144 | 22 | Fine silt |
| Danube km 950 | A | 72 | 48 | 91 | 69 | 101 | 900 | 159 | 17 | 150 | 26 | Medium silt |
| | B | 36 | 46 | 103 | 39 | 130 | 1072 | 157 | 20 | 149 | 20 | Medium silt |
| Danube km 1040 | A | 13 | 17 | 46 | 46 | 43 | - | 89 | 8 | - | - | Coarse sand |
| Danube km 1044.6 | A | 1090 | 30 | 24 | 26 | 100 | 794 | 63 | 13 | 116 | 21 | Medium silt |
| | B | 1900 | 27 | 0 | 19 | 75 | 721 | 40 | 17 | 108 | 25 | Medium silt |

*Notes on used codes: * = below detection limit; - = no data available; in the column of "layer" code A means the upper thin layer, and B codifies the lower thick layer.*

**Table 4. Heavy metals content in the soft bodies of the Unionidae (in ppm)**

| Sampling point | Species | Cu | Pb | Zn | Ni | V | Ba | Zr | Cr | Co | Th |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Roşu Lake | Anodonta cygnaea | 135.2 | 0 | 0 | 18 | 0 | 1296.3 | .226 | 28.3 | 1.13 | 0 |
| Merhei Lake | *Anodonta cygnaea* | 0 | 0 | 0 | 15 | 0 | 609 | 0 | 34 | 1 | 0 |
| Fortuna Lake | *Anodonta cygnaea* | 41 | 0 | 0 | 17 | 0 | 1583 | 1 | 32 | 2 | 0 |
| Meşteru Lake | *Unio pictorum* | 0 | 0 | 0 | 28 | 0 | 2316 | .75 | 33 | 3 | 0 |
| Danube km 866 | *Unio tumidus* | 0 | 2 | 0 | 25 | 0 | 3059 | 0 | 40 | 2 | 80 |
| Danube km 911 | *Unio tumidus* | 1346 | 2 | 0 | 24 | 0 | 1864 | 1 | 50 | 4 | 14 |
| Danube km 950 | *Unio pictorum* | 1205 | 4 | 0 | 29 | 2 | 2656 | 2 | 47 | 6 | 49 |
| Danube km 1030 | *Anodonta cygnaea* | 47 | 0 | 0 | 12 | 0 | 1597 | 0 | 29 | 1 | 37 |
| | *Unio tumidus* | 162 | 79 | 563 | 43 | 0 | 5736 | 0 | 7.6 | 6 | 176 |
| Danube km 1040 | *Unio pictorum* | 665 | 11 | 0 | 29 | 0 | 2017 | 1 | 62 | 3 | 33 |
| Danube km 1044.6 | *Unio pictorum* | 147 | 8 | 0 | 23 | 0 | 2041 | 0 | 31 | 3 | 50 |

Table 5. **Heavy metals content in mussel shells (ppm).**

| Sampling point | Species | Cu | Pb | Zn | Ni | V | Ba | Zr | Cr | Co | Sr | Cd |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roşu Lake | *Anodonta cygnaea* | 24 | 51 | 77 | 63 | 3 | 50 | 0 | 21 | 36 | 1000 | 9 |
| Meşteru Lake | *Pseudanodonta complanata* | 31 | 67 | 367 | 67 | 0 | 20 | 30 | 23 | 38 | 800 | 10 |
| | *Anodonta cygnaea* | 28 | 63 | 97 | 75 | 5 | 120 | 0 | 24 | 38 | 1200 | 10 |
| | *Unio pictorum* | 28 | 70 | 784 | 76 | 5 | 80 | 0 | 22 | 36 | 900 | 10 |
| Danube km 866 | *Unio tumidus* | 30 | 60 | 108 | 71 | 7 | 75 | 0 | 26 | 33 | 500 | 8 |
| Danube km 1030 | *Unio tumidus* | 21 | 67 | 92 | 71 | 5 | 25 | 0 | 21 | 32 | 450 | 10 |
| | *Anodonta cygnaea* | 22 | 56 | 86 | 69 | 5 | 25 | 0 | 23 | 33 | 250 | 9 |
| Danube km 1040 | *Unio pictorum* | 20 | 70 | 99 | 68 | 0 | 40 | 0 | 23 | 35 | 700 | 10 |
| Danube km 1044.6 | *Unio pictorum* | 27 | 77 | 82 | 70 | 3 | 20 | 0 | 21 | 40 | 450 | 8 |
| | *Anodonta cygnaea* | 31 | 56 | 88 | 67 | 7 | 140 | 25 | 20 | 37 | 800 | 9 |

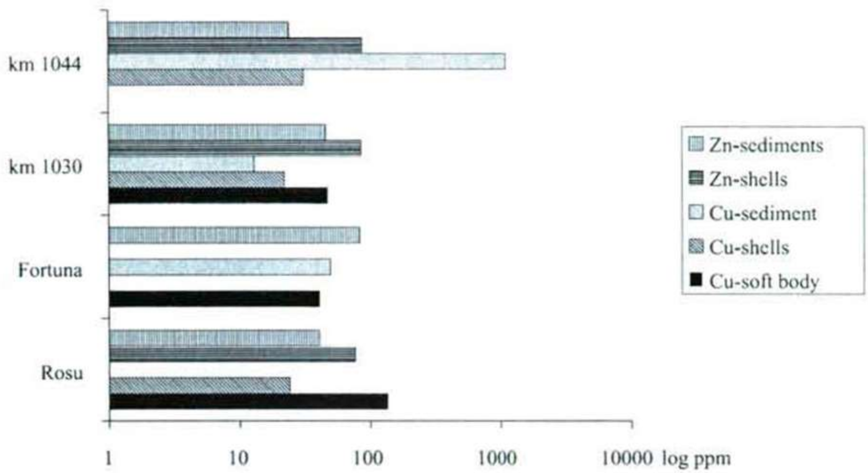



**Fig. 1. Content of Cu and Zn in the soft bodies and in shells of *Anodonta cygnaea* and in the upper thin layer of the sediments in Roşu and Fortuna Lakes and in the Danube km 1030 and km 1044.6.**

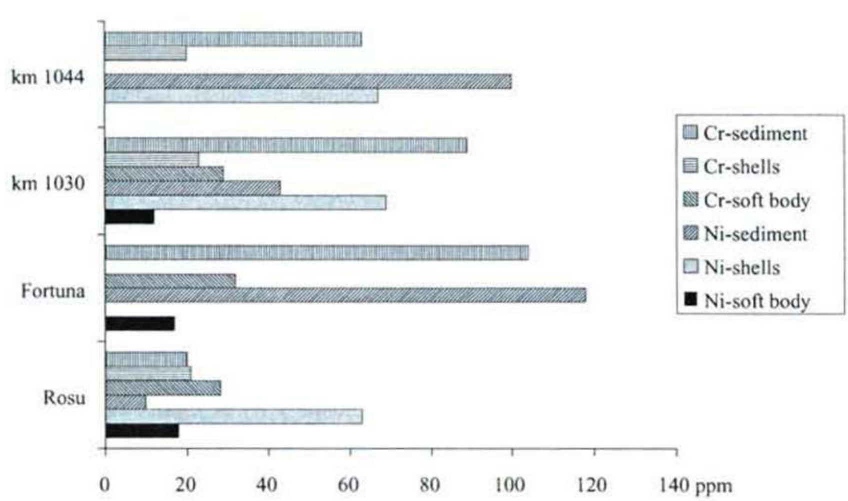



**Fig. 2. Content of Ni and Cr in the soft body and in shells of Anodonta *cygnaea* and in the upper thin layer of the sediments in Roşu and Fortuna Lakes and in the Danube km 1030 and km 1044.6.**

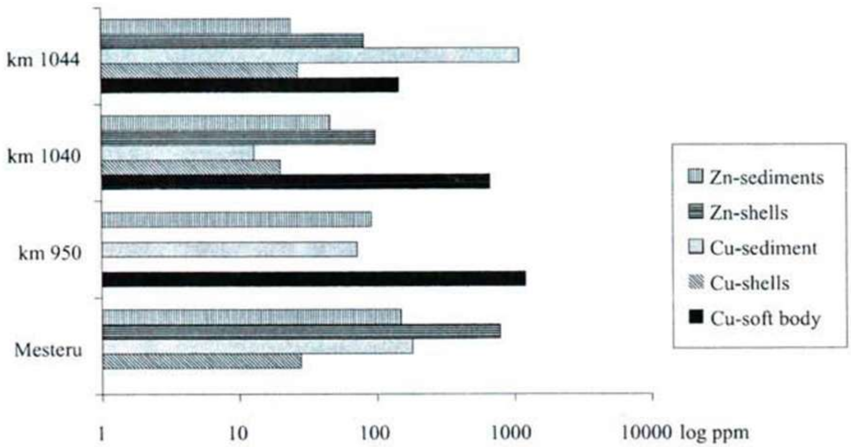



**Fig. 3. Content of Cu and Zn in the soft bodies and shells of *Unio pictorum*, and in the upper thin layer of the sediments in Meşteru Lake and in the Danube River km 950, km 1040 and km 1044.6.**

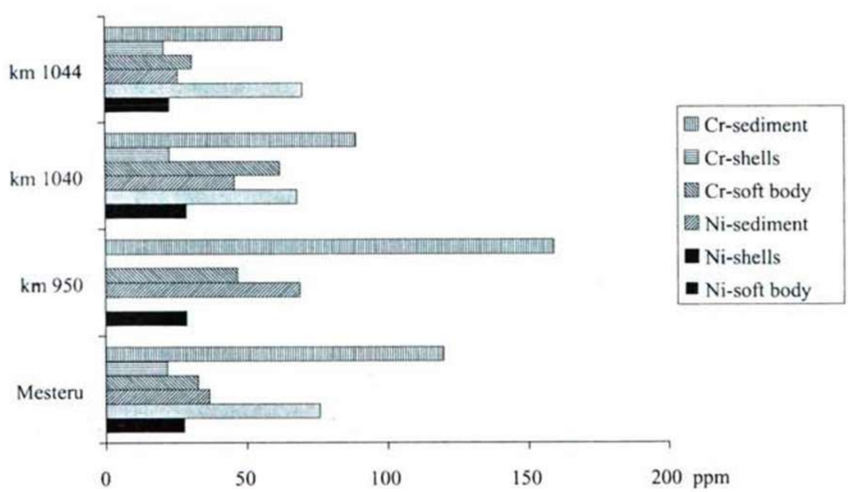



**Fig. 4. Content of Ni and Cr in the soft bodies and in shells of *Unio pictorum* and in the upper thin layer of the sediments in Meşteru Lake and in the Danube River km 950, km 1040 and km 1044.6**

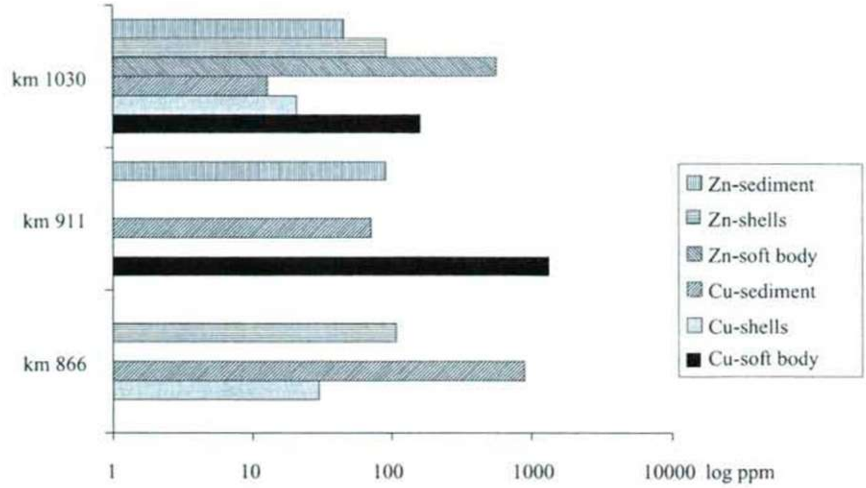



**Fig. 5. Content of Cu and Zn in the soft bodies and the shells of *Unio tumidus* and in the upper thin layer of the sediments from the Danube River, km 866, km 911 and km 1030**

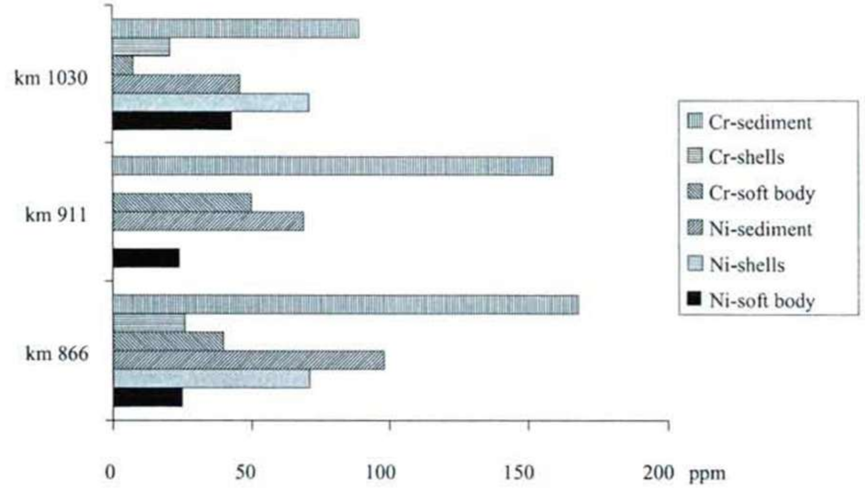



**Fig. 6. Content of Ni and Cr in the soft bodies and shells of *Unio tumidus* and in the upper thin layer of the sediments in the Danube River, km 866, km 950 and km 1030**

The same content in sediment is linked to higher values in the soft bodies in *U. pictorum*, less than *U. tumidus*, followed by *A. cygnaea,* while the content in shells are about the same. In the shells the content of Zn is higher than in sediments, and about in the same scale interval for all of the analysed species. With rare exceptions, the content of Cr in soft bodies is higher than in shells. In the same condition of sediments, the highest accumulation rate is showed by *U. pictorum,* followed by *A. cygnaea* and *U. tumidus.* In many cases the contents of the most hazardous metals are above the safety limits for these organisms, proving that heavy metals are a serious danger for the future, both for naiads and their environment.

## Conclusions

Although most areas of the Danube Delta Biosphere Reserve are in a good ecological condition, the age structure, the ratio of recently died individuals and the rarity of some unionacean species prove a certain degradation of the habitats. High values of heavy metals both in shells and soft bodies of these bivalves are also threat indices. Pollution and habitats degradation, although still not obvious, are among the future dangers that could affect the communities of this reserve.

## References


Burky, A.J., 1983, Physiological Ecology of Freshwater Bivalves. *The Mollusca, Ecology.* Russel-Hunter, W.D., eds., Academic Press, Inc. Orlando, San Diego, San Francisco, New York, London, Toronto, Montreal, Sydney, Tokyo, Sao Paulo, **6**, 281 - 330.

Fuller, S. L. H., 1974, Clams and Mussels (Mollusca, Bivalvia). *Pollution Ecology of Freshwater Invertebrates*, Hart C. W. Jr., Fuller, S.L.H. eds., Acad. Press, New York, San Francisco, London, 215 - 273.

Grossu, Al. V., 1962 - Mollusca; Bivalvia. *Fauna R.S.R.*, **3**, 3, Edit. Acad. Bucureşti.

Grossu, Al. V., 1993 - The catalogue of the molluscs from Romania. *Trav. Mus. Hist. nat. "Grigore Antipa"*, **33**,Bucuresti, 291 - 366.

Sárkány-Kiss, A., 1995 - Contribuţii la cunoaşterea faunei de moluşte acvatice din Delta Dunării. *Anal. St. Inst. Delta Dunării, Tulcea,* 5 - 8.

Sárkány-Kiss, A., Sîrbu, I., 1998, - Contribuţii la cunoaşterea asociaţiilor de moluşte acvatice din lacurile: Roşca, Rotundu, Belciug, Sărături-Murighiol şi Merhei (Rezervaţia Biosferei Delta Dunării). *Anal. St. Inst. de Cerc. Si Proiec. Delta Dunării*, Tulcea, IV (1-2), p. 85-93.

Sárkány-Kiss, A., Sîrbu, I., Hulea, O., 2000 - Expansion of the adventive species Anodonta woodiana (Bivalvia; Unionidae) in Central and Eastern Europe. Acta oecologica,VII (1-2), Univ. "Lucian Blaga", Sibiu, p. 49 - 57.

ANDREI SÁRKÁNY-KISS
"Babeş-Bolyai" University, Faculty of Biology and Geography,
Dept. of Ecology and Genetics,
5-7 Clinicilor St., RO 3400 Cluj-Napoca,
asarkany@hasdeu.ubbcluj.ro;

NICOLAE MIHĂILESCU
Institute of Geology,
19 Ecaterina Teodoroiu St., RO 78108 Bucharest

IOAN SÎRBU
"Lucian Blaga" University, Faculty of Sciences,
Dept. of Ecology and Environmental Protection,
31 Oituz St., RO 2400 Sibiu,
sirbui@yahoo.com;

# USING BIVALVES IN AN ALTERNATIVE TESTING METHOD OF FRESHWATER POLLUTION WITH HEAVY METALS

*Sárkány-Kiss Andrei and Braun Mihály*


## Abstract

In order to test an alternative method on freshwater pollution with heavy metals, individuals of *Unio crassus* were exposed in cages in polluted reaches of the Someş River. Their time-related bioaccumulation was registered and compared with control samples.


**Keywords:** biomonitoring, bioaccumulation, pollution ecology

## Introduction

The heavy metal content of the natural waters and of the sediments reflects the geochemical particularities of the examined place; their quantities usually do not exceed the tolerable values for the organisms. Due to human influences, the concentration of heavy metals may increase in the water, as well as in the sediment. The aquatic organisms accumulate these elements along the trophic chain. Molluscs are particularly well known as bioaccumulators of some of these metals (Fuller, 1974; Burky, 1983; Lakatos *et al.* 1990), taking them either directly from the environment, or indirectly through the food. The metals are stored in the soft parts of the body, as well as in the valves. It is known that the unionids molluscs are great plankton consumers and it was experimentally demonstrated that unicellular algae are able to retain during 14 days 78 - 98 % of the heavy metal content (in positive relation with the concentration) of the culture media (Nagy-Tóth, F. and Adriana Barna, 1982). Due to these qualities of the unionid molluscs, many authors suggest their use as bioindicators in this sense and recommend in a particular way the use of gills as indicator organs for the heavy metal bioaccumulation (Salánki *et al.* 1991).

Many studies demonstrate the sub-lethal and lethal toxic effects of these xenobiotics in different organisms, the modification of their metabolism (Nagy-Tóth, 1981), as well as the appearance of certain malformations (Szító, 1994) or other modifications in the cells of different organs, or even the modifications of the nervous system (Serfőző, 1993).

The indicator value of the aquatic organisms is more obvious in the case of the temporary and punctiform pollutions, in which neither the water nor the sediments contain an excessive quantity of pollutant, but the organisms still bear the sign of modifications produced by them (Moore - Ramamoorthy, 1984, ap. Dévai, 1993).

The Unionidae molluscs accumulate with a high intensity heavy metals, especially in gills. Because of their relative low mobility, these organisms are very good for testing the pollution degree of rivers with xenobiotics.

The catastrophic accidental pollution with cyanides and heavy metals caused by the Aurul industrial unit, from Bozânta Mare, determined a drastic effect on the aquatic communities from the Someş and Lăpuş rivers. Investigating the consequences during the years of 2000 - 2002 we noticed a serious load of heavy metals content in sediments. Afterwards the bioaccumulation was also researched, by using those organisms that are able to survive in lower reaches of the Someş River, namely fish and vascular plants. The latter showed high levels of heavy metals, but this could be due to sediments and biotecton settled on their organs, that are hard to be removed during the chemical analyses. Regarding the experiments with fish, in the year 2000 the metals' contents in the specimens captured in the exposed river sector were lower than those registered in individuals from the upper reaches. This proves that the fish that once lived in the polluted river sector died out, and were replaced after the environmental recovery, with other individuals belonging to different species, coming from upstream the river and its tributaries. These are the reasons why we decided to use bivalves as an alternative method of biomonitoring, but in the lower sector of the river this group is absent at present. Therefore individuals of *Unio crassus* Philipsson, 1788 had to be brought from the Lăpuş River Defile and afterwards from the Someş River Defile from Ţicău, which still shelter abundant populations of naiads, and exposed in underwater cages in the Someş River.

## Materials and method

In order to accomplish this experiment, on 18 October 2001 we collected manually 60 specimens from the Lăpuş Defile (Ohaba de Pădure sampling station). From these, 10 specimens were used as control samples (determining their heavy metal content), the other ones were exposed in the Someş River at Merişor, downstream the discharge of the Lăpuş River. These were held in plastic cages, and were removed for analyses in groups of 10 individuals after 7 days (on 25.10.2001), 21 days (on 08.11.2001) and 147 days (on 14.03.2002). After 08.11.2001 a very cold period followed and the Someş River froze, so we were unable to sample other individuals until the spring. The heavy metal content of muscles and gills were determined.

## Results and discussion

The results of the gills' analyses demonstrate a high bioaccumulation rate of copper and lead, in the first 7 days and, in a smaller degree, after 21 days. At this time the temperature of the water was higher, 7-8 $^0$C. After this date, when the temperature of the water has fallen close to 0 $^0$C, the mussels started to "hibernate" and catabolyze their own substances, so the heavy metal content decreased as well (**Tab. 1, Fig. 1, 2**) until the spring.

**Table 1. Heavy metal content of mussels in 2001**

| **Sample** | | | **Cu** | **Pb** |
|---|---|---|---|---|
| Mussels | **Sampling site** | **Date** | **mg/kg** | **mg/kg** |
| Unio crassus/muscle – control | Lăpuş - Defile | 18.10.2001. | 14 | 1 |
| Unio crassus/gills- control | Lăpuş - Defile | 18.10.2001. | 144 | 14 |
| U. crassus/gills | Someş - Merişor | 25.10.2001. | 259 | 19 |
| U. crassus/muscle | Someş - Merişor | 25.10.2001. | 10 | <1 |
| U. crassus/gills | Someş - Merişor | 08.11.2001. | 171 | 27 |
| U. crassus/muscle | Someş - Merişor | 08.11.2001. | 5 | <1 |
| U. crassus/gills | Someş - Merişor | 14.03.2002. | 77 | 13 |
| U. crassus/muscle | Someş - Merişor | 14.03.2002. | 8 | <1 |

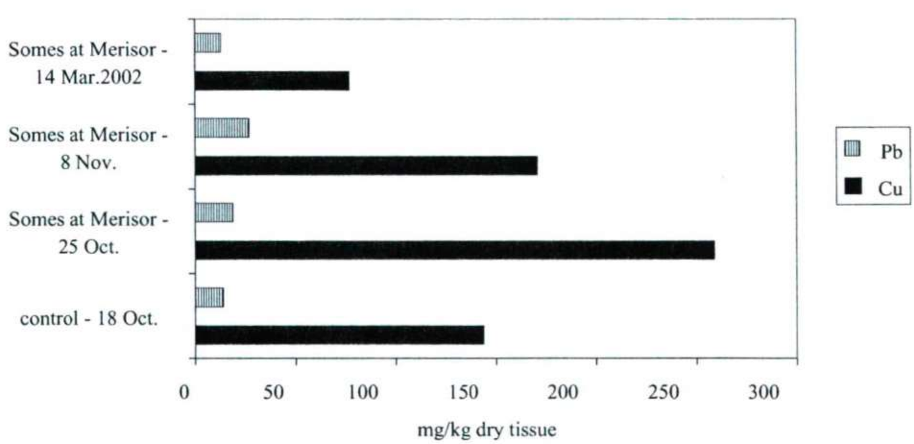



**Fig. 1. The dynamics of heavy metal bioaccumulation in gills**

In a very sharp contrast, the analyses of muscles illustrates another pattern, namely that all samples, despite the period, showed lower contents of heavy metals than the control. Led is continuously decreasing, while the copper registered an increased value in spring 2002, compared to the fall of 2001. These peculiarities suggested that the gills are much sensitive in heavy metals monitoring than muscles.

This first experience proved that the method is applicable only in the warm seasons, during which the bivalves are active. During the summer of 2002 the study was repeated in a similar manner but, finding out that the controls already have a certain amount of heavy metals, because of the residual mining waters discharged from the upper sectors, we used individuals from the Ţicău Defile, the Someş reach upstream the confluence with the Lăpuş tributary. The results are not available yet, but during the summer in only 9 weeks 60 % of these bivalves died, and the others were seriously weakened, having a pale colour of the tissues, as compared to the control samples.

Is worth mentioning that after the first 7 days the Sr content of the gills has increased. According to Coote & Trompetter (1995) one of the possible reasons of this increase should be the effect of stress.

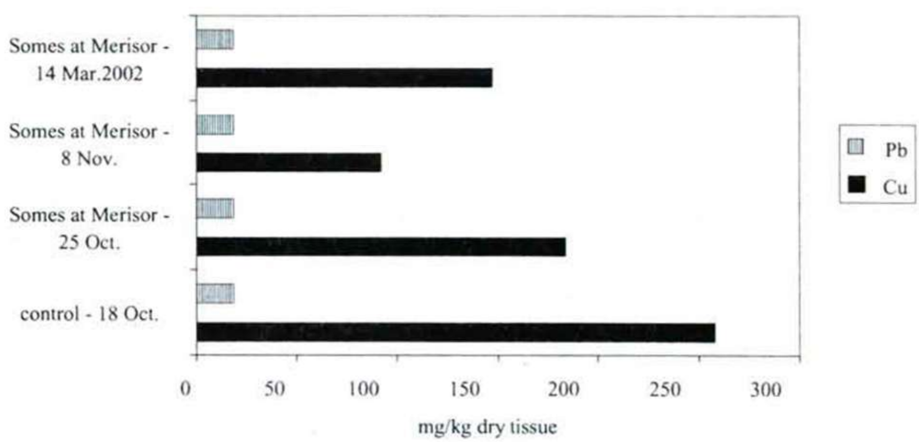



Fig. 2. The dynamic of heavy metal bioaccumulation in muscle

## Acknowledgement

The study was supported by the Inco Copernicus Project ICA2-1999-10065.


## References


Barna, A., Nagy-Tóth, F. (1993) - Analize ficofiziologice în zona Zlatnei. (Pshycophysiological analyses in the Zlatna zone) - St. cerc. biol., Seria biol. veget., 45, 1, 107 - 117.

Burky, A.J. (1983) - Physiological Ecology of Freshwater Bivalves. The Mollusca, Ecology, eds. W.D. Russel-Hunter, Academic Press, Inc., Orlando, San Diego, San Francisco, New York, London, Toronto, Montreal, Sydney, Tokyo, Sao Paulo, 6, 281 - 330.

Coote, G.E. and W. J. Trompetter (1995): Proton microprobe studies of fluorine distribution in mollusc shells. Nuclear Instruments and Methods in Physics Research B, 104, 333–338.

Dévai, Gy., Dévai, I., Czégény, I., Harman, B., Wittner, I. (1993): A bioindikáció értelmezési lehetőségeinek vizsgálata különböző terheltségű északkelet - magyarországi víztereknél. (Studies on the interpretation of bioindication phenomena.) - Hidrológiai Közlöny, 73, 4, 202 - 211.

Lakatos, Gy., Mészáros, I., Nagy, D., Sándor, I., Szűcs, L. (1990): Use of freshwater mussels (*Unio tumidus* Retz.) to biomonitor the metal loading of river Sajó in Hungary - Proc. Intern. Symp. Ecox. Munich (Edits. C. Steinberg & A. Kettrup), 203 - 211.

Nagy - Tóth, F., Barna, A. (1982): Analiza algofiziologică a unor ape metalopoluate. - St. cerc. biol., Seria biol. veget., 34, 2, 134 - 139.

Nagy - Tóth, F. and Barna, A. (1981): Phycophysiological and toxic effects of some trace elements and heavy metals. - Studia Univ. Babes - Bolyai, Biologia, 26, 1, 12 - 21.

Salánki, J., Tupaev, T.M. and Nichaeva, M. (1991): Mussel as a test animal for assessing environmental pollution and the sub - lethal effect of pollutants. - Reprint. F.: Jeffrey, D.W. and Madden (eds.), Bioindicators and Environmental Management., Acad. Press, London. 235 - 244.

Sárkány - Kiss, A. (1992): The mullusk fauna of the river Mureş as bio-indicator of pollution. - Abstr. 11th Intern. Malacol. Congr., Siena 1992 - F. Giusti & G. Manganelli eds., 502 - 503.

Sárkány-Kiss, A., Fodor, A., Ponta, M., 1997, - Bioaccumulation of certain heavy metals by unionidae molluscs in Criş/Körös rivers. *Tiscia - Monograph series,* Hamar, J. & Sárkány - Kiss, A. edit., Szolnok - Szeged - Tg.Mureş, 209 - 219.

Sárkány-Kiss, A., Macalik, K., 1999 Bioaccumulation of certain toxic metals by fish and unionidae shells in River Someş/Szamos. Tiscia monograph series, Sárkány - Kiss, A. & Hamar, J. edits., Szolnok - Szeged - Tg.Mureş, 269 - 273.

Serfőző, J. (1993): Necrotic effects of the xenobiotics accumulation in the central nervous system of a crayfish (*Astacus leptodactylus* Eschz.). - Acta biol. Szeged, 39, 23 - 38.

Szitó, A. (1994) - Monitoring in aquaculture. - First Dutch - Hungarian Course on Biomonitoring in Hungarian Waters: Application an Training, Göd, Hungary.

Wachs, B. (1985): Bioindicators for the heavy metal load of river ecosystems. - in Heavy metals in water organisms (Ed. Salánki, J.), Akad. Kiadó, Budapest, 179 - 190.

ANDREI SÁRKÁNY-KISS
"Babeş-Bolyai" University, Faculty of Biology and Geography,
Dept. of Ecology and Genetics,
5-7 Clinicilor St., RO 3400 Cluj-Napoca,
asarkany@hasdeu.ubbcluj.ro;

BRAUN MIHÁLY
University of Debrecen
Department of Inorganic and Analytical Chemistry
H-4010 Debrecen P.O.Box 21, Hungary
braun@tigris.klte.hu

TISCIA monograph series (2002), 6, 99-148

# THE ECOLOGICAL STATE OF THE TISA RIVER AND ITS TRIBUTARIES INDICATED BY THE MACROINVERTEBRATES

*András Szító*

## Abstract

People start to be aware of the possibility to use the tolerant species as environment indicators. Covering up the ecological demand of different species, we would be able to understand more and more from their signals and to use them in qualification of the ecological changes.

The ecological qualification may be on a species level only. The upper species categories are not enough for this work. The lack of benthic invertebrates may be often due to the lack of the sediment, like in the Upper Tisa Region.

The high individual density of a species may be caused by the optimal food source for them, but extraordinary high in hypertrophic situation sometimes. Oligochaete species often produce extreme high individual density, but the species richness is reduced to one or two species only. *Limnodrilus hoffmeisteri* is the most tolerant species in our investigated regions, it is present in hypertrophic relations.

The lack of the tolerant indicator species in an ecosystem may indicate continuous or temporary oxygen depletion, moreover high organic material pollution or chemical poisoning.

The monitoring data show a temporary picture about the state of the investigated ecosystems. The continuous and complex works may detect and present the ecological changes.

Clean water indicator, moderate tolerant and tolerant species were identified.

**Keywords:** river ecology, invertebrata, benthos, indicator species

## Introduction

The biomonitoring is a continuous quality investigation and control system, which shows the environmental quality changes by the species composition and individual density changes in the communities. The scientific background of the monitoring is the fact that environmental factors affect the plants and animals. The affecting biological and abiotic environmental factors provide them with the opportunity to find their essential conditions, to settle down and to reproduce.

The biologists already recognized more than 150 years before that the demands of the organisms for the environmental factors are different. The most sensitive organisms were used as environmental quality indicators, because the positive environmental changes are productive for their presence, reproduction and individual density. Their response to negative effects results in their individual decrease and the disappearance from the ecosystem. This realization is used by the specialists for the qualification of different water ecosystems. The qualification of the different water ecosystems by indicator species is a complementary, but important method for the chemical analyses.

The quality of a water ecosystem is determined by chemical and biological parameters of the water and sediment, but their complex effect could be indicated by the quality and quantity changes of the communities. The biomonitoring produces temporary information about the state of the investigated ecosystem, but this periodical data collection offers a continuous picture. The presence of species, their individual density or disappearance are such informations which can be used for qualification of the changes in the community structures and the ecological state changes. If we know the environmental demands of the species, we are able to describe the quality of the ecosystem by their presence or disappearance.

We use a lot of plant and animal species as environmental indicators, especially the steno-types, because they indicate one or two environmental factors only, which are as follows: pH, light, temperature, food, water currency, chemical pollution. The eury-type species can survive the extreme effects, therefore they were not used as indicators.

In the last years scientists try to use the taxons over the species (genus, family etc.). These people don`t think that it is a mistake. The reactions of the species are different to the environmental factors inside a family or a genus. For example: there are Oligochaete and Chironomid species which indicate the clean water, the others the polluted waters, moreover a lot of Oligochaete and Chironomid species live only in standing waters, in running waters, but we can find some other species living both in standing and running waters. The qualification of the ecosystems by the presence or disappearance of the taxons over species is an ostrichism only, instead the relations of the education and training of specialists to solve this complex education problem at state level (*Szító, 1998a*).

If the river was able to eliminate the organic and inorganic pollutants, the species composition of the community signalized this process downstream (*Nuttall et al., 1974*). The species composition and structure of macrobenthos was used for evaluation of water quality of Scioto River System (*Olive et al., 1975*). The Chironomids were used at Hungary in the River Tisa monitoring similarly (*Szító, 1981*).

The big and continuous, organic pollution results in oxygen depletion on the sediment surface in the big rivers too, thereafter the macrobenthos community disappears (*Dratnal et al., 1980*).

The tolerant species of the macroinvertebrates were used for indicating the environment quality changes by the heavy metal pollution (Waterhouse et al., 1985). Increasing the number of private farms resulted in the pollution of the small streams with organic materials, in which a new macrobenthos community formed with tolerant species (Schofield et al., 1989). The community structure of a river changed hard in the town part. The sensitive species for environment changes disappeared from here and only the tolerant ones were present. The fauna regenerated slowly downstream the town (Hynes et al., 1989). Similar changes of the macroinvertebrate communities were recognized in the Transylvanian rivers and river systems *(Szító, 1995, Szító et al., 1997; 1999; Szító, 1998a,b; 1999a-c, 2000a-c)*.

Increasing the trophic level by non-point pollution effects of the agriculture, therefore the individual density of the macrobenthos community increased too. The consumers did not follow the hard developed epilithic algae in individual densities (*Delong et al., 1998*).

The species number was much lower on the chemically or physically disturbed parts, than on the undisturbed sites. The larvae drifted from the drifted parts to the nondisturbed sites. The species composition showed better the disturbance downstream, than the changes of the heavy metal concentration (*Ruse et al., 2000*).

Our monitoring work may give up-to-date pictures about the environment quality changes in different rivers and the recommendations help the modifications of the negative progressions.

## Material and Methods

Qualitative samples were taken from the surface of the stone and gravel piece by washing into a drifting net in each profiles. Sampling sites were at various distances from the left, the right bank and in the main current as well when it was possible.

Each sample was washed through a metal screen with pore mesh size of 250 µm and preserved in 3-4 % formol solution. The retained material was separated into groups of Oligochaetes, Chironomids and other groups of animals with a Zeiss stereomicroscope in the laboratory, with a 4 to 6 times magnification, and animals were preserved in 80 % ethylic alcohol.

For taxonomic identification the following works were used: (*Bíró, 1981; Brinkhurst and Jamieson, 1971; Cranston et al. 1983; Ferencz, 1979, Fittkau, 1962; Fittkau et al. 1983; Pinder et al. 1983; Pop, 1943, 1950*).

## Results and Discussion

### The species presence, disappearance, individual density

*Dikerogammarus haemobaphes fluviatilis* and *Rivulogammarus balcanicus dacicus* (Amphipoda) formed the shrimp fauna in the River Mureş/Maros in 1991. This species were present between the region of source and Suseni. The effects of both the reservoir upper Târgu Mureş and the sewage water of the town resulted in a big change in the species composition. Downstream Târgu Mureş, the tolerant Caenis sepcies appeared near Sintimbru only, when the quantity of the pollutants decreased because of the self purification of the river (*Table 1*).

Oligochaete were tolerant to pollution and the environment quality changes therefore its species richness was high. *Limodrilus profundicola* by Târgu-Mureş, *Isochaeta virulenta* by Deva and *Limnodrilus hoffmesiteri* by Deva had high individual density and showed hypertrophic environment in this river part. The deep sediment was rich in organic material, too (*Table 2*).

The presence of predator Chironomid species depended on the food source, therefore they indicated the environment quality only indirectly.

The epiphytic Chironomid species were rare between the source region and Rastolita in this clean river part. The epilithon was very poor on the surface of gravels and boulders, the food source was poor. No species appeared between Târgu-Mureş and Alba Julia, in spite of the river bed covered by gravels in this river part (*Table 3*). Benthic Chironomid species appeared first in Rastolita, because some sediment was found here. *Microchironomus bicolor, Microtendipes chloris and Polypedilum convictum* indicated the clean river part by Rastolita. *Chironomus thummi (fluviatilis), Chironomus riparius, Chironomus plumosus, Chironomus semireductus, Dicrotendipes nervosus, D. pulsus* and *Paratendipes albimanus* needed eutrophic environment, therefore they were tolerant to organic pollution. Some tolerant Chironomid species disappeared between Gura Aries and the influent, *Cryptochironomus redekei, Paracladopelma camptolabis, Tripodura (Polypedilum) scalaenum* and *Robackia demeijerei* were present (*Table 3*).

The control investigations showed in 1999 that both the species richness and individual density of Oligochaete increased between the source region and Senetea, between Ungheni and Sintimbru they decreased and they increased by Pecica (*Figure 1*). Both the species richness and the individual density of Chironomid increased between the source region and Senetea, which was the clean river part in 1991, which fact indicated sedimentation and pollution in this area, too. The epilithic Chironomid fauna increased by Senetea, 9 species were found here and they were present in sampling places downstream.

The number of benthic Chironomid species was 5 in Senetea, and 11 in Pecica (*Figure 1*). Both the species richness and individual density indicated rich food sources and eutrophic relations. The species richness with 9 and 12 epilithic species in Senetea and Salard area was that same as in Vintu de Jos, but the high species abundance was formed by benthic Chironomids by Pecica. Presence of Cladotanytarsus, Dicrotendipes, Chironomus and Einfeldia species indicated standing water relations near the river banks and high diversity of the investigated river parts. The lack of *Beckidia zabolotzkyi, Paralauterborniella nigrohalteralis, Paratendipes albimanus, Paratendipes (intermedius) nudisquama* indicated that the River Mureş/Maros had communal and industrial pollution from Târgu-Mureş to Pecica (*Table 4*).

During the investigations of the Someş/Szamos River System between 1-22, August, 1992, the presence of *Isochaeta mischaelseni* indicated clean water river part, while its disappearance showed the increase of organic and other pollutants. Eutrophic and hypertrophic relations were indicated by *Limnodrilus hoffmesiteri, Tubifex ignotus* and *Psammoryctides moravicus* between Cluj and Gherla. Data show that the self purification of the river was not effective enough on an about 50 km long distance. The pollution level was lower between Beclean and the mouth, than on the upper river part (*Table 5*).

*Anatopynia plumipes* and *Apsectrotanypus trifascipennis* (Chironomidae, Tanypodinae) indicated clean and cold water river part. Species of Orthocladiinae were found as living in epiphyton and epilithon. Their species richness showed the high diversity of the investigated river part, but low individual density of *Eukiefferiella brevicalcar, Eukiefferiella coerulescens, Euorthocladius (Orthocladius) thienemanni, Orthocladius saxicola, Propsilocerus paradoxus, Psectrocladius barbimanus, Psectrocladius obvius, P. simulans, Monodiamesa bathiphyla* and *Corynoneura scutellata* indicated clean water in the Someşul Cald/Meleg Szamos River and R. Someşul Rece/Hideg Szamos, and upstream Cluj. The phytophyle Chironomid species disappeared between Cluj and Gherla because of hypertrophic relations (*Table 6*).

Continuous increasing of the number of benthic Chironomids upstream Cluj indicated the sedimentation process and some food source for them. They disappeared between Cluj and Gherla because of hypertrophic environmental relations in sediment, their both low species richness and individual density showed a polluted river part from the confluence with Arin brook to the mouth (*Table 6*).

The ecological state of the Crişul Alb/Fehér Körös River was investigated in 1994. Regarding the Oligochate fauna, *Limnodrilus claparedeianus, Limnodrilus hoffmesiteri* and *Limnodrilus profundicola* indicated eutrophic relations between Brad and Ineu, the pollution level decreased by Chişineu Criş because of the self purification (*Table 7*). The Chironomid fauna indicated eutrophic relations, the organic material content of the sediment was moderate, the fauna was diverse because of the high species abundance (*Table 8*).

The complex evaluation of the ecological state of the Crişul Negru/Fekete Körös River was made in 1994. Both the species richness and individual density of Oligochaete and Chironomids indicated eutrophic relations between Poiana and Sarkad. The presence of the only one species of *Branchiura sowerbyi* and the lack of other species showed the temporary oxygen depletion (*Table 9*). The species richness of benthic Chironomid fauna was high only in Tinca, but the larvae of this species lived in epilithon, like in Poiana, Ştei (Petru Groza) and Borz (*Table 10*).

The ecological state of the Crişul Repede/Sebes Körös River was investigated in 1995. Oligochaete appeared in Şaula, 3443 ind./m$^2$ of *Limnodrilus hoffmeisteri* indicated eutrophic relations here, but the individual density of *Limnodrilus claparedeianus, Limnodrilus udekemianus* and the *Tubifex* sp. confirmed our conclusion. The individual density of Oligochate was low between Ciucea and Fughiu, they disappeared by Stâna de Vale, but showed eutrophic relations by Cheresig (*Table 11*).

The phytophyle Chironomid fauna showed moderate eutrophic relations. *Orthocladius saxicola* and *Cricotopus trifasciatus* indicated the clean water part (Spring area, Aleşd, Ciucea, Oşorhei). The individual density was low for all species.

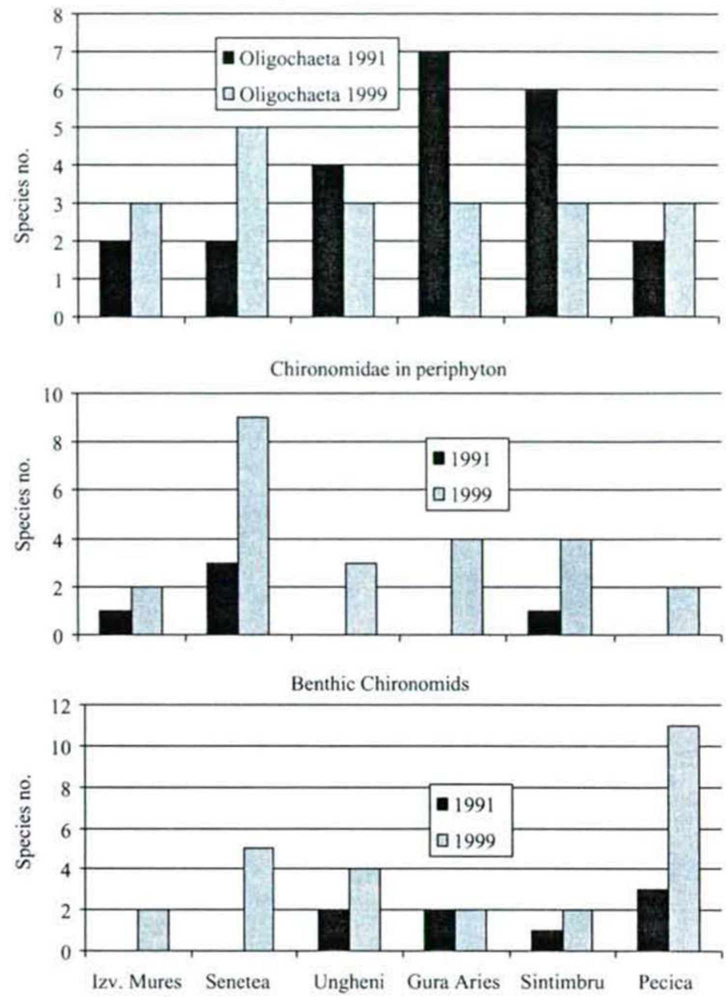



**Fig. 1. Invertebrata species number in the River Mureş/Maros**

The benthic Chironomid fauna showed diverse relations. Chironomus sp., *Cladotanytarsus mancus* and *Cryptochironomus redekei* were frequent in the sediment near the banks, *Paratendipes (intermedius) nudisquama* and *Paracladopelma rolli* appeared, indicated the rivers, which were found in Mureş/Maros earlier (*Table 12*).

A very important data collection was made in the international expedition, to cover up the Oligochaete and Chironomid fauna on the Upper Tisa Region and its tributaries, because there were no similar data and information from here.

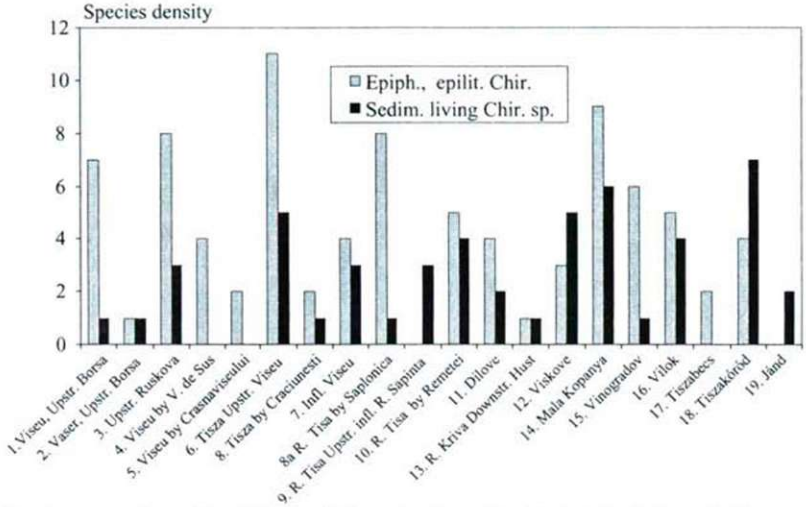



**Fig. 2. Species composition of the Chironomid fauna in Upper Tisa Region (10-19 Sep., 2000)**

The river beds were covered by boulders and gravels, sediment was found only rarely and it was not characteristic of this region. That was the reason why the macrozoobenthos was poor in species and individuals, too. The species and individual richness was bigger in the epiphyton than in the sediment.

Pollutants cannot concentrate because of lack of the sediment, but these materials were transported downstream and diluted. Anthropogenic pollution effects were not detected during the expedition, but the Chironomid species *Prodiamesa olivacea* was not present in the river at Rahiv. The disappearance of this species showed that some pollution effects existed periodically in this river region (*Figure 2*).

The investigations and the indicator species showed that Ung, Latorica, Ondava, Laborec Rivers and Bodrog River were mostly clean. The rivers were polluted on some sampling areas as follows:

The River Latorica had no benthos by Chop upstream (place 6). The River Ung by Pavlovce (place 7) was rich in food sources for benthos. 18 individuals of *Chironomus riparius*, 12 ind. of *Polypedilum nubifer* and 13 ind. of Tripodura scalaenum were present here. The presence of *Chironomus riparius* and Polypedilum species, and their individual richness showed a probability of temporary human pollution (Table *13*).

River Latorica by Velky Kapusany downstream: the sediment was deep, clay *Limnodrilus hoffmeisteri* (Oligochaeta) and *Chironomus riparius* was present with 12 ind./m$^2$ and indicated communal pollution.

The presence of 6 individuals of the predator chironomid Apsectrotanypus suggested a food richness for them in the Laborec River by Koskovce downstream (place 9). Those Chironomid species which were commonly living both in the periphiton and sediment were present.

The Laborec River was poor in species by Stretavka downstream (place 11). The deep and organic material rich sediment had a poor zoocoenose. 6 individuals of the tolerant *Limnodrillus hoffmeisteri*, 8 ind. of *Chironomus riparius*, and 4 ind. of both the *Polypedilum nubifer* and *Polypedilum convictum* showed an eutrophic environment on the left bank river side (Table *14*).

The sedimement of Latorica River was rich in organic material by Zlatin (place 12), but the left river bank side was bad in species. 6 ind. of *Limnodrilus hoffmeisteri*, 8 ind. of *Chironomus riparius*, and 4 ind. of both the *Polipedilum convictum* and *Polypedilum nubifer* were present here. Both the species and their individual richness indicated the probability of the richness of the organic materials in the sediment (*table 14*).

River Bodrog by Vinicky showed deep muddy sediment (place 13). Only one individum of *Branchiura sowerbyi* (Oligochaete) was found. It was the only one from the investigated area during the expedition. We do not know its earlier data from these rivers, and its presence indicated the food richness in sediment, as well as *Limnodrilus hoffmeisteri*, which was present with 13 individuals, too. The *Corethra plumicornis* and *Cloëon dipterum* were also present here. Moreower, 5 chironomid species were detected, the presence and high individual richness of *Chironomus riparius* showed an eutrophic sediment (Table *14*).

The mouth area of River Ondava by Brechov had deep sediment. The Gomphus flavipes was the only species here. Some species presence of Oligochate and chironomid would be prognostized with high individual richness by the environment, but we dont know the cause of their lack.

River Bodorog by Bodrogolaszi (place 19). The sediment was rich in organic materials by right side of the river bank. The very tolerant *Limnodrilus hoffmeisteri* (Oligochaete) species was present only, but the tolerant chironomid species disappeared.

River Bodrog by Felsőberecki (place 18). The sediment was deep, with aerobic surface. The lack of the fauna was surprising (*Table 14*).

River Bodrog by Bodrogkeresztúr, mouth area (place 20). It was rich in organic materials. 4 species found. The *Limnodrilus hoffmeisteri* was the only Oligochaete species present here, 3 chironomid species were present with 1-2 individuals only. The fauna was poor both in species and individuals (Table *14*).

The sediment fauna was formed by Perla sp and 10 chironomid species in River Laborec by Certizne upstream, in spring area. All the species were clean water indicators.

The presence of 6 individuals of the predator chironomid Apsectrotanypus suggested a food richness for them in River Laborec by Koskovce downstream (place 9). Those Chironomid species were present which were commonly living both in the litophiton and sediment.

## Tables

**Table 1. Changes of the species and their individual density from the spring to the estuary of the River Mureş/Maros**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Profile (section) | 1 | 2 | 3 | 4 | 5 |
| 2 | Sampling site | Izv. Mureş | Senetea | Suseni | Sărmaş | Răstoliţa |
| 3 | | | | | Individ/m$^2$ | |
| 4 | Crustacea | | | | | |
| 5 | Amphipoda | | | | | |
| 6 | Dicerogammarus haemobaphes fluv. Mart. | 564 | 195 | 24 | | |
| 7 | Rivulogammarus balc. dac. Dobr.-Man. | | 36 | 72 | 24 | |
| 8 | Insecta | | | | | |
| 9 | Ephemeroptera | | | | | |
| 10 | Siphlonurus arnatus Etn. | | 18 | 18 | 186 | 114 |
| 11 | Siphlonurus lacustris Etn. | | | 12 | | 12 |
| 12 | Siphlonurus linneanus Etn. | | | | 54 | 6 |
| 13 | Ameletus inopinatus Etn. | | | | 24 | |
| 14 | Baëtis atrebatinus Etn. | | | | 18 | |
| 15 | Baëtis muticus L. | | | | 6 | 12 |
| 16 | Baëtis niger L. | | | | 6 | |
| 17 | Baëtis rodani Pict. | | | 6 | 6 | |
| 18 | Baëtis pumilus Burn. | | | 12 | | 18 |
| 19 | Baëtis scambus Etn. | | 84 | 72 | 510 | 18 |
| 20 | Ecdyonurus insignis Etn. | | | | 54 | 6 |
| 21 | Ephemerella notata Etn. | | | | 36 | |
| 22 | Caenis horaria L. | | | | 12 | 42 |
| 23 | Caenis macrura Steph. | | | | | 6 |
| 24 | Caenis moesta Bengtss. | | | | | |
| 25 | Caenis rivulorum Etn. | | | | | 12 |
| 26 | Caenis robusta Etn. | | | | | 6 |
| 27 | Potamanthus luteus L. | | | | 12 | 6 |
| 28 | Simuliidae | | | | | |
| 29 | Simulium ornatum Meig. | | 6 | | | 204 |
| 30 | Simulium sublacustre Davies | | | | | 6 |
| 31 | Simulium equinum L. | | | | | 6 |

| 1 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Târgu Mureş | Ungheni | Gheja | Gura Arieş | Sîntimbru | Alba Iulia | Deva | Zam | Pecica | Szeged |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 16 | | | | | | | | | | |
| 17 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 21 | | | | | | | | | | |
| 22 | | | | | 6 | | | | | |
| 23 | | | | | | | | | | |
| 24 | | | | | 6 | | | | | |
| 25 | | | | | 18 | | | | | |
| 26 | | | | | 6 | | | | | |
| 27 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 30 | | | | | | | | | | |
| 31 | | | | | | | | | | |

Table 2. Oligochaeta species and their individual density in the River Mureş/Maros (in 1991)

| 1 | Sampling site | Izv. Mureş | Senetea | Suseni | Sărmaş | Răstoliţa |
|---|---|---|---|---|---|---|
| 2 | Oligochaeta | | | | | Ind./m$^2$ |
| 3 | *Aurodrilus limnobius Bretsh.* | | | | | |
| 4 | *Branchiura sowerbyi Bedd.* | | | | | |
| 5 | *Eiseniella tetraedra Mich.* | | | | | |
| 6 | *Isochaeta virulenta Point.* | | | | | 6 |
| 7 | *Limnodrilus claparedeianus Rat.* | | | | | |
| 8 | *Limnodrilus hoffmeisteri Clap.* | | | | | 6 |
| 9 | *Limnodrilus profundicola Brinkh.* | 6 | | | | 60 |
| 10 | *Limnodrilus udekemianus Clap.* | | | | | 6 |
| 11 | *Lumbricillus lineatus Mich.* | | 6 | | | |
| 12 | *Peloscolex speciosus Hrabe* | | | | | |
| 13 | *Potamothrix hammoniensis Brinkh.* | | | | | |
| 14 | *Potamothrix vejdowskyi Hrabe* | 12 | 6 | | | 12 |
| 15 | *Thalassodrilus prostatus Kn÷ll.* | | | | 6 | 12 |
| 16 | *Tubifex ignotus Stolz* | | | | 6 | 18 |
| 17 | *Tubifex nevaensis Mich.* | | | | | |
| 18 | Ind. | 18 | 12 | 0 | 12 | 120 |
| 19 | Species richness | 2 | 2 | 0 | 2 | 7 |

| 1 | Târgu Mureş | Ungheni | Gherla | Gura Arieş | Sîntimbru | Alba Iulia | Deva | Zam | Pecica | Szeged |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | | | |
| 3 | | | | 30 | | | | | | |
| 4 | | | | | | | | 6 | | 42 |
| 5 | | | | 12 | | | | | | |
| 6 | | | | | | | 4152 | | | |
| 7 | | | | | 6 | | | | | |
| 8 | 48 | 804 | 180 | 48 | 12 | 61 | 30856 | 894 | | 58 |
| 9 | 7152 | 54 | 348 | | 30 | | | | 24 | |
| 10 | | 12 | 6 | | 18 | | 30 | | | 30 |
| 11 | | | | | | | | | | |
| 12 | | | | 48 | | | | | | |
| 13 | | | | 6 | 12 | | 66 | | | |
| 14 | | 12 | | 12 | | | 766 | 18 | | 30 |
| 15 | | | | | | | | | | |
| 16 | | | 6 | | | | | | | |
| 17 | 6 | | 24 | 12 | 6 | | 24 | | 48 | |
| 18 | 7206 | 882 | 564 | 168 | 84 | 61 | 35894 | 918 | 72 | 160 |
| 19 | 3 | 4 | 5 | 7 | 6 | 1 | 6 | 3 | 2 | 4 |

Table 3. Chironomid species as environment indicators (Mureş/Maros, 1991)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Profile (section) | 1 | 2 | 3 | 4 | 5 |
| 2 | Sampling site | Izv. Mureş | Senetea | Suseni | Sărmaş | Răstoliţa |
| 3 | | ind./m$^2$ | | | | |
| 4 | Chironomidae | | | | | |
| 5 | Procladius choreus Meig. | | | | | 18 |
| 6 | Tanypus punctipennis Meig. | | | | | |
| 7 | Thienemannimyia lentiginosa Fries | | | | | |
| 8 | Thienemannimyia northumbrica Edw. | | | | | |
| 9 | Thienemannimyia sp. | | | | | |
| 10 | Brillia modesta Meig. | | | | | 6 |
| 11 | Cricotopus bicinctus meig. | | 24 | | | |
| 12 | Cricotopus sylvestris Fabr. | | 6 | | | |
| 13 | Metriocnemus hygropetricus Kieff. | | 6 | | | |
| 14 | Prodiamesa olivacea Meig. | 6 | | | | 36 |
| 15 | Chironomus fluviatilis Lenz | | | | | |
| 16 | Chironomus plumosus L. | | | | | |
| 17 | Chironomus riparius Meig. | | | | | |
| 18 | Chironomus semireductus Lenz | | | | | |
| 19 | Cryptochironomus redekei Krus. | | | | | 24 |
| 20 | Dicrotendipes nervosus Staeg. | | | | | |
| 21 | Dicrotendipes pulsus Walk. | | | | | |
| 22 | Einfeldia pectoralis Kieff. | | | | | |
| 23 | Microchironomus bicolor Zett. | | | | | 6 |
| 24 | Microtendipes chloris Meig. | | | | | 186 |
| 25 | Paracladopelma camptolabis Kieff. | | | | | |
| 26 | Paratendipes albimanus Meig. | | | | | 6 |
| 27 | Polypedilum convictum Walk. | | | | | 114 |
| 28 | Polypedilum nubeculosum Meig. | | | | | |
| 29 | Tripodura (Polypedilum) scalaenum Schr. | | | | | 6 |
| 30 | Robackia demeijerei Krus. | | | | | |

| 1 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Târgu Mureş | Ungheni | Gherla | Gura Arieş | Sîntimbru | Alba Iulia | Deva | Zam | Pecica | Szeged |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | 102 | | | | 6 | | | | | |
| 6 | 6 | | | | | | | | | |
| 7 | | | | | 6 | | | | | |
| 8 | | | | | 6 | | | | | |
| 9 | | | | | 6 | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | 12 | | 6 | | | | | | | |
| 16 | 192 | | | | | | | | | |
| 17 | 78 | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | 24 | | | 24 | | | | | | |
| 20 | | | 24 | | | | | | | |
| 21 | | | 18 | | | | | | | |
| 22 | 6 | | | | | | | | | |
| 23 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 25 | | | | | | 6 | | | 6 | |
| 26 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 28 | | 312 | | | | | | | | |
| 29 | 96 | 6 | 6 | 12 | 18 | | | 6 | 126 | 12 |
| 30 | | | | | | | | | 18 | |

**Table 4. Benthic and epilithic Chironomid species and their individual density in different parts of the River Mureş in 1999**

| | Izvorul Mureş | Senetea | Sălard | Ungheni | Sintimbru | Gura Arieş | Sîntimbru | Vinţu de Jos | Pecica |
|---|---|---|---|---|---|---|---|---|---|
| | 27. 07 | 27. 07 | 27, 07 | 02. 09 | 15. 09 | 06.09 | 26. 09 | 19. 09 | 21. 09 |
| Species | | | | Ind./m$^2$ | | | | | |
| Nematoda | | | | | | | | | 47 |
| Oligochaeta | | | | | | | | | |
| Amphicaeta leydigii Tauber | 3 | | | | | | | | |
| Ophidonais serpentina Müller | 17 | 13 | | | | | | | |
| Enchytraeus buchholzi Vejd. | | | 3 | | | | | | |
| Limnodrilus hoffmeisteri Claparéde | | 33 | | | | 80 | 163 | 23 | 10 |
| Limnodrilus profundicola Verrill | | | | | | 27 | | | |
| Potamothrix vejdovskyi Hrabe | | 63 | 10 | 23 | | | | | |
| Pristina bilobata Bretsch. | 550 | 277 | 23 | | 10 | | 2387 | 17 | |
| Stylaria lacustris Linnaeus | | | | 27 | 10 | | | | 27 |
| Tubifex nevaensis Mich. | | 340 | 33 | 120 | 10 | 53 | 227 | 420 | 23 |
| Oligochaeta (ind./m$^2$) | 570 | 727 | 70 | 170 | 30 | 160 | 2777 | 460 | 60 |
| Oligochaeta (species richness) | 3 | 5 | 4 | 3 | 3 | 3 | 3 | 3 | 4 |
| Chironomidae | | | | | | | | | |
| Tanypodinae | | | | | | | | | |
| Psilotanypus imicola Kieff. | | 7 | | | | | | | |
| Tanypus punctipennis Meig. | | | | 3 | | 177 | 687 | 143 | 37 |
| Krenopelopia binotata Wied. | 7 | | 50 | | 13 | 3 | | 20 | 10 |
| Corynoneurinae | | | | | | | | | |
| Corynoneura validicornis Kieff. | | | | | | | 3 | | |
| Orthocladiinae | | | | | | | | | |
| Acricotopus lucens Staeg. | | | | 3 | | | | | |
| Briophaenocladius nitidicolis Goetgh. | | | | | | | | 3 | |
| Cricotopus bicinctus Meig. | | 80 | 223 | | | | 70 | 77 | 7 |

**Table 4. (continued)**

| | Izvorul Mureş | Senetea | Sălard | Ungheni | Sîntimbru | Gura Arieş | Sîntimbru | Vinţu de Jos | Pecica |
|---|---|---|---|---|---|---|---|---|---|
| | 27. 07 | 27. 07 | 27, 07 | 02. 09 | 15. 09 | 06.09 | 26. 09 | 19. 09 | 21. 09 |
| Species | Ind./$m^2$ | | | | | | | | |
| Cricotopus cylindraceus Kieff. | | 157 | 70 | 3 | | | | | |
| Cricotopus fuscus Kieff. | | | | | | | | | |
| Eukiefferiella brevicalcar Kieff. | | | | | | | | 3 | |
| Eukiefferiella claripennis Lundbeck | | | 60 | | | | | | |
| Eukiefferiella coerulescens Kieff. | | 37 | | | | | | | |
| Eukiefferiella devonica Edwards | | | 47 | | | | | | |
| Heleniella thienemanni Gowin | 17 | 3 | | | 20 | | | 7 | |
| Monodiamesa bathyphila Kieff. | | | | | | 3 | | 120 | |
| Nanocladius bicolor Zett. | | 3 | | | | | | 20 | |
| Orthocladius barbatus Cindea | | | 3 | | | | | | |
| Orthocladius olivaceus Kieff. | | | | | | | | 7 | |
| Orthocladius rivulorum Kieff. | | | 60 | | | | | | |
| Orthocladius saxicola Kieff. | | 153 | 1527 | | 140 | 3 | 30 | 750 | 180 |
| Parakiefferiella bathophila Kieff. | | | 17 | | | | | | |
| Prodiamesa olivacea Meig. | | 13 | | | | | | | |
| Prodiamesa rufovittata Goetgh. | | | 10 | | | | | | |
| Psectrocladius psilopterus Kieff. | | 47 | 260 | | 300 | | | | |
| Trissocladius brevipalpis Kieff. | | | | | | | | 397 | |
| Zavrelimyia nubila Meig. | | | 60 | | | | | | |
| Orthocladiinae (Ind./$m^2$) | 23 | 500 | 2387 | 10 | 473 | 187 | 827 | 1663 | 293 |
| Orthocladiinae (Species richness) | 2 | 9 | 12 | 3 | 4 | 4 | 5 | 12 | 2 |
| Chironominae | | | | | | | | | |
| Chironomini | | | | | | | | | |

**Table 4. (continued)**

| | Izvorul Mureş | Senetea | Sălard | Ungheni | Sintimbru | Gura Arieş | Sintimbru | Vinţu de Jos | Pecica |
|---|---|---|---|---|---|---|---|---|---|
| | 27. 07 | 27. 07 | 27, 07 | 02. 09 | 15. 09 | 06.09 | 26. 09 | 19. 09 | 21. 09 |
| Species | Ind./$m^2$ | | | | | | | | |
| Chironomus riparius Meig. | | | | | | 20 | | | |
| Chironomus salinarius Kieff. | | | | 3 | | | 10 | 13 | 10 |
| Cryptochironomus redekei Krus. | | | 3 | | | | | | |
| Cryptotendipes pseudotener Goetgh. | | | | | | | | | 3 |
| Dicrotendipes nervosus Staeg. | | | | | | | | | |
| Einfeldia dissidens Walk. | | | | | | | 3 | 7 | 10 |
| Einfeldia pectoralis Kieff. | | | | | | | | | |
| Parachironomus tenuicaudatus Mall. | | 3 | | | | | | | |
| Paracladopelma camptolabis Kieff. | | 33 | | 17 | | 123 | 330 | 207 | 520 |
| Polypedilum convictum Walk. | | 10 | 13 | 3 | | | | 27 | 760 |

**Table 4. (continued)**

| | Izvorul Mureş 27. 07 | Senetea 27. 07 | Sălard 27, 07 | Ungheni 02. 09 | Sîntimbru 15. 09 | Gura Arieş 06.09 | Sîntimbru 26. 09 | Vinţu de Jos 19. 09 | Pecica 21. 09 |
|---|---|---|---|---|---|---|---|---|---|
| Species | Ind./$m^2$ | | | | | | | | |
| Polypedilum nubeculosum Meig. | | | | | | | | | |
| Polypedilum sordens v.d. Wulp | | 3 | 950 | | | | | | 3 |
| Tripodura scalaenum Schrank | | | 7 | 80 | | | | | 167 |
| Tanytarsini | | | | | | | | | |
| Cladotanytarsus mancus Walk. | 3 | | | | | | | | 23 |
| Rheotanytarsus curtistylus Goetgh. | | | 20 | | 27 | | 13 | 33 | 40 |
| Tanytarsus curticornis Kieff. | | | | | | | | | 17 |
| Tanytarsus gregarius Kieff. | | | | | 37 | | | | 57 |
| Simulida | 13 | 10 | | | | | | | |
| Chironominae (Ind./$m^2$) | 3 | 50 | 993 | 103 | 63 | 123 | 357 | 287 | 1610 |
| Species richness | 2 | 5 | 4 | 4 | 2 | 1 | 4 | 5 | 11 |

**Table 5. Oligochet fauna and the individual density in the Someş River System (1-22 August, 1992)**

| 1 | | Eiseniella | Enchytraeus | Isochaeta | Limno. | Limno. | Pelosc. | Pelosc. | Pot. |
|---|---|---|---|---|---|---|---|---|---|
| 2 | | tetra. | buchholzi | michaelseni | hoffm. | udek. | speciosus | ferox | hamm. |
| 3 | | ind./m2 | | | | | | | |
| 4 | 1. Someş Cald. | 4 | | 7 | 0 | 0 | 0 | | |
| 5 | 2. Someş Rece | 34 | | 21 | 0 | 0 | 0 | | |
| 6 | 3. Upstr. Cluj | | | | 2 | 0 | 1 | | |
| 7 | 4. Downstr. Cluj | | | | 9000 | 0 | | | |
| 8 | 5. Upstr. Gherla | | | | 7660 | 301 | | | |
| 9 | 6. Confl. With Arin brook | 5 | 1 | 1 | 4 | | | | |
| 10 | 7. Sângeorzi Băi | 4 | | 4 | | | 4 | | |
| 11 | 8. Downstr. Năsăud | | | | | | | | |
| 12 | 9.Downstr. Beclean | | | | 683 | | | | |
| 13 | 10. Downstr. Dej | | | | 2 | | | 1 | |
| 14 | 11. Someş Odorhei | | | | 13 | | | | 1 |
| 15 | 12. Sălsig | | | | 20 | | | | |
| 16 | 13. Pomi | | | | 12 | | | | 1 |
| 17 | 14. Păuleşti | | | | 4 | 12 | | | |
| 18 | 15. Vetiş | | | | 65 | | | | |
| 19 | 16. V. namény | | | | 96 | | | | |
| 20 | Frequency (%) | 7 | 1 | 7 | 22.8 | 3.2 | 3.2 | 1 | 3.2 |

| 1 | Potam. | Psammoryct. | Psammoryct. | Stilodr. | Stylaria | Tubifex | Tubifex | Tubifex | Species |
|---|---|---|---|---|---|---|---|---|---|
| 2 | vejd. | morav. | barbatus | heringe. | lac. | nevae. | ignotus | tubifex | |
| 3 | | | | | | | | | |
| 4 | 0 | 0 | | 0 | 0 | 0 | 0 | | 2 |
| 5 | 11 | 0 | | 4 | 0 | 0 | 0 | | 4 |
| 6 | 2 | 0 | | | 1 | 1 | 0 | | 5 |
| 7 | | 0 | | | | | 1000 | | 2 |
| 8 | | 1204 | | | | | 3400 | | 4 |
| 9 | | | | | | | | | 4 |
| 10 | | | | | | | | | 3 |
| 11 | | | | | | | 2 | | 1 |
| 12 | 33 | | | | | | 532 | | 3 |
| 13 | 9 | | | | | 17 | 7 | | 5 |
| 14 | | | | | | 7 | | | 3 |
| 15 | | | 1 | | | 4 | 14 | 4 | 5 |
| 16 | | | 1 | | | 68 | 34 | 6 | 5 |
| 17 | | | | | | 12 | 7 | | 4 |
| 18 | | | | | | 4 | 12 | | 3 |
| 19 | | | | | | 36 | 22 | | 3 |
| 20 | 7 | 1 | 3.2 | 1 | 1 | 15.6 | 18.7 | 3.2 | |

**Table 6. Chironomid species and their density in the Someş/Szamos River System (1-22 August, 1992)**

| 1 | | | | | | | | Sampling sites | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Feeding type | | 1. S. Cald | 2. S. Rece | 3. Upstr. Cluj | 4. Downstr. Cluj | 5. Upstr. Gherla | 6. Confl. with Arin brook | 7. Sângeorzi Băi |
| 3 | | Species | | | | | | ind./$m^2$ | |
| 4 | | **Tanypodinae** | | | | | | | |
| 5 | Pre- | *Anatopynia plumipes (Fries, 1823)* | | | 2 | | | | |
| 6 | dators | *Apsectrotanypus trifascipennis (Zett., 1838)* | 1 | 2 | | | | | |
| 7 | | *Macropelopia notata Meig.* | | | 1 | | | | |
| 8 | | *Natarsia punctata Fabr.* | | | 1 | | | | |
| 9 | | *Procladius choreus Meig.* | | | | | | | |
| 10 | | *Tanypus punctipennis (Meig., 1818)* | | | 1 | | | | |
| 11 | | **Orthocladiinae** | | | | | | | |
| 12 | P | *Brillia longifusca (Kieff., 1921)* | | | 1 | | | | |
| 13 | h | *Bryophaenocladius nitidicollis Goetgh.* | | | | | | 1 | |
| 14 | y | *Cricotopus bicinctus Meig.* | | | 11 | | | | |
| 15 | t | *Cricotopus fuscus Kieff.* | | | | | | | |
| 16 | o | *Cricotopus trifascia* | | | | | | | |
| 17 | p | *Eukieferiella brevicalcar Kieff.* | 2 | 1 | | | | | |
| 18 | h | *Eukiefferiella clypeata Kieff.* | | | | | | | |
| 19 | i | *Eukiefferiella coerulescens Kieff.* | | 1 | | | | | |
| 20 | l | *Eukiefferiella gracei (Edw., 1929)* | | | | | | | |
| 21 | e | *Eukiefferiella lobifera Goetgh.* | 1 | 1 | | | | | |
| 22 | | *Eukiefferiella similis Goetgh.* | 11 | 5 | 1 | | | | |
| 23 | f | *Euorthocladius) Orthocladius thienemanni Kieff.* | | | 1 | | | | |
| 24 | a | *Isocladius (Cricotopus) sylvestris Fabr.* | 1 | | | | | | |
| 25 | u | *Nanocladius bicolor Zett.* | | | 1 | | | | |
| 26 | n | *Orthocladius saxicola Kieff.* | | | 6 | | | | |
| 27 | a | *Orthocladius sp.* | | | 7 | | | | |
| 28 | | *Paracladius conversus Walk.* | | | 8 | | | | |
| 29 | | *Propsilocerus danubialis (Botn. et Albu, 1956)* | 1 | | 2 | | | | |
| 30 | | *Propsilocerus paradoxus Lundstr.* | | 1 | | | | | |
| 31 | | *Psectrocladius barbimanus Edw.* | 1 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | 8. Downstr. Năsăud | 9. Downstr. Beclean | 10. Downstr. Dej | 11. Someş Odorhei | 12. Sălsig | 13. Pomi | 14. Păuleşti | 15. Vetiş | 16. V.namény |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | 1 | |
| 10 | | 1 | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | 2 | | | | | | | | |
| 14 | 3 | 12 | 39 | 127 | 12 | | | | |
| 15 | | | | | | | | | 1 |
| 16 | | | 1 | | | | | | |
| 17 | | | | | | | | | |
| 18 | 2 | | | | | 36 | 21 | 5 | 22 |
| 19 | | | | | | | | | |
| 20 | 2 | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | 2 | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | 8 | | | | | | | | |
| 25 | | | 16 | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | 3 | | | | | | | | |
| 29 | | 1 | | | | | | | 2 |
| 30 | | | | | | | | | |
| 31 | | | | | | | | | |

**Table 6. (continued)**

| 1 | | | Sampling sites | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Feeding type | | 1. S. Cald | 2. S. Rece | 3. Upstr. Cluj | 4. Downstr. Cluj | 5. Upstr. Gherla | 6. Confl. with Arin brook | 7. Sângeorzi Băi |
| 32 | | *Psectrocladius obvius (Walker, 1856)* | 1 | | | | | | |
| 33 | | *Psectrocladius simulans* | | | 3 | | | | |
| 34 | | *Smittia aterrima Meig.* | | | | | | | |
| 35 | | *Thienemannia gracilis (Kieff., 1909)* | 1 | | 1 | | | 1 | |
| 36 | | *Zalutschia mucronata (Brundin, 1949)* | | | | | | | |
| 37 | | **Diamesinae** | | | | | | | |
| 38 | | *Monodiamesa (Prodiamesa) bathypila (Kieff., 1918)* | | | 2 | | | | |
| 39 | | *Prodiamesa olivacea Meig.* | | | 1 | | | 7 | |
| 40 | | *Pseudodiamesa branichii Now.* | 1 | | | | | | |
| 41 | | **Corynoneurinae** | | | | | | | |
| 42 | | *Corynoneura scutellata Win.* | 4 | | | | | | |
| 43 | | **Ind. density of phytophile fauna** | 24 | 9 | 45 | 0 | 0 | 9 | 0 |
| 44 | | Species richness | 10 | 5 | 13 | 0 | 0 | 3 | 0 |
| 45 | | **Chironominae** | | | | | | | |
| 46 | | **Chironomini** | | | | | | | |
| 47 | B | *Chironomus annularius Meig.* | | | | | | | 22 |
| 48 | e | *Chironomus riparius Meig.* | | | 5 | | 1 | | |
| 49 | n | *Cryptochironomus defectus Kieff.* | | 2 | | | | | |
| 50 | t | *Cryptochironomus holsatus (Lenz, 1959)* | | | 1 | | | | |
| 51 | h | *Cryptochironomus redekei Krus.* | | | | | | | |
| 52 | i | *Endochironomus tendens (Fabr., 1775)* | | | | | | | |
| 53 | c | *Microtendipes chloris (Meig., 1818)* | | | 10 | | | | |
| 54 | | *Microtendipes pedellus d. Geer* | | | 20 | | | | |
| 55 | f | *Microtendipes tarsalis Walk.* | | | 8 | | | | |
| 56 | a | *Paracladopelma camptolabis (Kieff., 1913)* | | 6 | | | | | |
| 57 | u | *Polypedilum convictum Walk.* | | | | | | | |
| 58 | n | *Polypedilum laetum Meig.* | | | 2 | | | | |
| 59 | a | *Stictochironomus crassiforceps Kieff.* | | | 38 | | | | |

| 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 8. Downstr. Năsăud | 9. Downstr. Beclean | 10. Downstr. Dej | 11. Someş Odorhei | 12. Sălsig | 13. Pomi | 14. Păuleşti | 15. Vetiş | 16. V.namény |
| 32 | | | | | | | | | |
| 33 | | | | | | | | | |
| 34 | 6 | | | | | | | | |
| 35 | | | | | | | | | |
| 36 | | | | | | | | | 2 |
| 37 | | | | | | | | | |
| 38 | | | | | | | | | |
| 39 | | | | | | | | | |
| 40 | | | | | | | | | |
| 41 | | | | | | | | | |
| 42 | | | | | | | | | |
| 43 | 28 | 13 | 56 | 127 | 12 | 36 | 21 | 5 | 27 |
| 44 | 8 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 4 |
| 45 | | | | | | | | | |
| 46 | | | | | | | | | |
| 47 | | | | | | | | | |
| 48 | | | | 1 | | | | | |
| 49 | | | | | | | | | |
| 50 | | | | | | | | | |
| 51 | 2 | | 26 | | | | 3 | | |
| 52 | 1 | | | | | | | | |
| 53 | | | | | | | | | |
| 54 | | | | | | | | | |
| 55 | | | | | | | | | |
| 56 | | | | | | | | | |
| 57 | | | 3 | 1 | | | | | |
| 58 | | | | | | | | | |
| 59 | | | | 1 | | | | | |

**Table 6. (continued)**

| 1 | | | Sampling sites | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Feeding type | | 1. S. Cald | 2. S. Rece | 3. Upstr. Cluj | 4. Downstr. Cluj | 5. Upstr. Gherla | 6. Confl. with Arin brook | 7. Sângeorzi Băi |
| 60 | | *Tripodura (Polypedilum) scalaenum (Schrank, 1803)* | | 45 | | | | | |
| 61 | | *Zavreliella marmorata (v. d. Wulp, 1858)* | | | 6 | | | | |
| 62 | | **Tanytarsini** | | | | | | | |
| 63 | | *Micropsectra apposita (Walker, 1856)* | | | | | | 1 | |
| 64 | | *Micropsectra junci (Meig., 1818)* | | | 2 | | | | |
| 65 | | *Paratanytarsus lauterborni Kieff.* | | | | | | | |
| 66 | | *Rheotanytarsus curtistylus Kieff.* | 1 | | | | | | |
| 67 | | *Tanytarsus gracilentus (Holmgr., 1883)* | | | 2 | | | | |
| 68 | | *Tanytarsus gregarius Kieff.* | 43 | 6 | 6 | | | | |
| 69 | | **Ind. density of Chironomini** | 44 | 59 | 100 | 0 | 1 | 1 | 22 |
| 70 | | Species richness | 3 | 4 | 11 | 0 | 1 | 1 | 1 |
| 71 | | Total ind. density | 69 | 70 | 150 | 0 | 1 | 10 | 22 |
| 72 | | Species density | 13 | 10 | 30 | 0 | 1 | 4 | 1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | 8. Downstr. Năsăud | 9. Downstr. Beclean | 10. Downstr. Dej | 11. Someş Odorhei | 12. Sălsig | 13. Pomi | 14. Păuleşti | 15. Vetiş | 16. V.namény |
| 60 | | | 5 | 8 | | 2 | | 2 | 1 |
| 61 | | | | | | | | | |
| 62 | | | | | | | | | |
| 63 | | | | | | | | | |
| 64 | | | | | | | | | |
| 65 | | 1 | | | | | | | |
| 66 | | | | | | | | | |
| 67 | | | | | | | | | 2 |
| 68 | | | | | | | | | |
| 69 | 3 | 1 | 34 | 11 | 0 | 2 | 3 | 2 | 3 |
| 70 | 2 | 1 | 3 | 4 | 0 | 1 | 1 | 1 | 2 |
| 71 | 31 | 15 | 90 | 138 | 12 | 38 | 24 | 8 | 30 |
| 72 | 10 | 4 | 6 | 5 | 1 | 2 | 2 | 3 | 5 |

**Table 7. Quantitative data of the Oligochaete in the River Fehér Körös (Crişul Alb, in 1994)**

| | Sampling places | | | | |
|---|---|---|---|---|---|
| | Criş | Brad | Aciuţa | Ineu | Ch. Criş |
| Species | ind./m$^2$ | | | | |
| *Limnodrilus claparedeianus* | | 171 | 302 | 3006 | 40 |
| *Limnodrilus hoffmeisteri* | | 2313 | 845 | 306 | |
| *Limnodrilus profundicola* | | 428 | 181 | 982 | 30 |

**Table 8. Chironomid fauna in the River Crişul Alb ( Fehér Körös, in 1994)**

| | Species | Spring area | Brad | | | | Ch. Criş | Aciuţa | Ineu | Gyula |
|---|---|---|---|---|---|---|---|---|---|---|
| | | main current | near the bank | fresh alder leaves in water | navvy holes | river bed | | | | |
| | | ind./m$^2$ | | | | | | | | |
| P | *Brillia longifusca K.* | | 8 | 19 | | | | | | |
| h | *Cladopelma laccophila K.* | | | | 19 | | | | | 11 |
| y | *Cricotopus sylvestris Fabr.* | | | | | | | | | 8 |
| t | *Eukiefferiella coerulescens K.* | | | | | | 4 | | | |
| o | *Limnophies prolongatus K.* | | 15 | | | | | | | |
| p | *Orthocladius olivaceus K.* | 11 | | | | | | | | |
| h | *Orthocladius saxicola K.* | | | 4 | | | 8 | | 19 | |
| i | *Parakiefferiella bathophila K.* | | | | | | | 19 | | |
| l | *Paralauterborniella nigrohalteralis Mall.* | | | | | | | 4 | | |
| e | *Psectrocladius barbimanus Edw.* | | | | | 446 | | 4 | | |
| | *Rheocricotopus effusus Walk.* | | 8 | | | | | | | |
| s | *Syndiamesa branickii Now.* | | 4 | | | | | | | |
| p | *Thienemanniella flavescens Edw.* | | 4 | | | | | | | |
| e | *Thienemannimyia lentiginosa Fries* | 79 | 38 | | 132 | 4 | | 87 | 42 | |
| c. | Ind. density | 91 | 76 | 23 | 151 | 450 | 12 | 114 | 61 | 19 |
| | Species number | 2 | 6 | 2 | 2 | 2 | 2 | 4 | 2 | 2 |

**Table 8. (continued)**

| | Species | Spring area | Brad | | | | Ch. Criş | Aciuţa | Ineu | Gyula |
|---|---|---|---|---|---|---|---|---|---|---|
| | | main current | near the bank | fresh alder leaves in water | navvy holes | river bed | | | | |
| B | *Chironomus thummi (fluviatilis Lenz)* | | | | | 11 | | | | |
| e | *Chironomus plumosus Linnaeus* | | | | 8 | 4 | | | | |
| n | *Cladotanytarsus mancus Walk.* | 4 | | | | | 4 | | | |
| t | *Conchapelopia pallidula Mg.* | | | | 4 | 15 | | | | |
| h | *Cryptochironomus defectus K.* | | | | 49 | | | | | |
| i | *Cryptochironomus redekei Krus.* | 4 | | | 38 | | | 23 | 15 | |
| c | *Cryptotendipes anomalus K.* | | | | 57 | | | | 4 | 4 |
| | *Dicrotendipes nervosus Staeg.* | | | | | | | | | 19 |
| s | *Dicrotendipes pulsus Walk.* | | | | | | | | | 8 |
| p | *Dicrotendipes tritomus K.* | | | | | | | | 4 | |
| e | *Einfeldia insolita K.* | | | | 4 | | | | | |
| c | *Einfeldia pectoralis K.* | 4 | | | 4 | | | | | |
| i | *Endochironomus intextus Walk.* | | | 11 | | | | | | |
| e | *Krenopelopia binotata Wied.* | | | | | | | | 4 | |
| s | *Macropelopia nebulosa Mg.* | 4 | | | | | | | | 42 |
| | *Micropsectra praecox Mg.* | 110 | 8 | | | | | | 8 | |
| | *Micropsectra trivialis K.* | | | | | | | | | 8 |
| | *Microtendipes chloris Mg.* | | | | | | | 4 | 4 | |
| | *Parachironomus arcuatus Goetgh.* | | | | 23 | | | | | |
| | *Parachironomus monochromus v.d. Wulp* | | | | | | | | | 11 |
| | *Paratanytarsus lauterborni K.* | 4 | 4 | | | 4 | | 8 | | |
| | *Pentapedilum sordens v. d. Wulp* | 4 | 8 | 34 | | 30 | | | | |

**Table 8. (continued)**

| Species | Spring area | Brad | | | | Ch. Criş | Aciuţa | Ineu | Gyula |
|---|---|---|---|---|---|---|---|---|---|
| | main current | near the bank | fresh alder leaves in water | navvy holes | river bed | | | | |
| *Polypedilum minutum Krug.* | | | 15 | 0 | 34 | 11 | 23 | | |
| *Polypedilum nubeculosum Mg.* | | 4 | 4 | 23 | | | | | 11 |
| *Polypedilum nubifer Skuse* | | | | 8 | | | | | |
| *Tripodura (Polypedilum) scalaenum Schr.* | 11 | 15 | | | 64 | | | 4 | 4 |
| *Procladius choreus Mg.* | | 4 | | 15 | | | | | |
| *Robackia demeijerei Krus.* | | | | | | 8 | | | |
| *Tanypus punctipennis Mg.* | | | | 19 | | | | | |
| *Tanytarsus curticornis K.* | 8 | | | 8 | 11 | | 4 | 4 | 11 |
| *Tanytarsus gregarius K.* | | | | | | | 4 | | |
| Ind. density | 151 | 42 | 64 | 257 | 174 | 23 | 64 | 45 | 117 |
| Species number | 9 | 6 | 4 | 13 | 8 | 3 | 6 | 8 | 9 |
| | | | | | | | | | |
| Total ind./m2 | 242 | 117 | 144 | 408 | 646 | 34 | 178 | 106 | 136 |
| Species richness | 11 | 12 | 6 | 15 | 10 | 5 | 10 | 10 | 11 |

**Table 9. Species richness and quantitative data of the Oligochaete in the River Fekete Körös (Crişul Negru), River Kettős Körös and River Hármas Körös (August 10-17, 1994)**

| Species | Sampling places | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poiana | Ştei | Borz | Tinca | Zerind | Gyula | Sarkad | Békés, R. Kettős K. | Csongrád, R. Hármas K. |
| | Ind./$m^2$ | | | | | | | | |
| *Branchiura sowerbyi* | | | | 59 | | | | 59 | |
| *Eiseniella tetraedra* | 200 | | 51 | | | | | | |
| *Limnodrilus claparedeianus* | | 401 | | | | | | | |
| *Limnodrilus hoffmeisteri* | | 987 | 89 | | 182 | | | | 44 |

**Table 10. Chironomid fauna in the River Crişul Negru (Fekete Körös, in 1994)**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Species | Poiana | | Ştei | | Borz | Tinca | Zerind | | Sarkad |
| | | bank | gravels | sandy sediment | gravels | gravels | sediment | sediment | phyto-tecton | clay sediment |
| P | *Brillia longifusca K.* | | 8 | | | | | | | |
| h | *Brillia modesta Mg.* | 4 | | | | | | | | |
| y | *Briophaenocladius nitidicollis Goetgh.* | | 4 | | | | | | | |
| t | *Cricotopus bicinctus Mg.* | | | | | 4 | | | | |
| o | *Cricotopus trifascia Edw.* | | | | 4 | | | | | |
| p | *Eukiefferiella longicalcar K.* | | | | 8 | | | | | |
| h | *Eukiefferiella similis Goetgh.* | | | | 8 | | | | | |
| i | *Eukiefferiella tshernovskii Pankr.* | | | | 106 | | | | | |
| l | *Limnophies pusillus Eaton* | | 4 | | | | | | | |
| e | *Metriocnemus hygropetricus K.* | | 8 | | | | | | | |
| | *Orthocladius olivaceus K.* | | | | 23 | | | | | |
| s | *Orthocladius saxicola K.* | | | | 15 | | | | | |
| p | *Parakiefferiella bathophila K.* | | | 4 | | | | | | |
| e | *Paralauterborniella nigrohalteralis Mall.* | | | | 4 | 8 | 4 | | 8 | |
| c | *Potthastia longimana K.* | 4 | | | | | | | | |
| i | *Prodiamesa olivacea Mg.* | 87 | | | | | 4 | | | |
| e | *Propsilocerus danubialis Botnariuc et Albu* | | | | 11 | | | | | |
| s | *Psectrocladius barbimanus Edw.* | | | | 19 | | | | | |
| | *Synorthocladius semivirens K.* | | 8 | | | | | | | |
| | *Thienemanniella clavicornis K.* | 4 | | | | | | | | |
| | Ind. density | 98 | 30 | 4 | 196 | 11 | 8 | 0 | 8 | 0 |
| | Spec. number | 4 | 5 | 1 | 9 | 2 | 2 | 0 | 1 | 0 |

**Table 10. (continued)**

| | Species | Poiana | | Ştei | | Borz | Tinca | Zerind | | Sarkad |
|---|---|---|---|---|---|---|---|---|---|---|
| | | bank | gravels | sandy sediment | gravels | gravels | sediment | sediment | phyto-tecton | clay sediment |
| B | *Arctopelopia sp.* | 4 | | | | | | | | |
| e | *Chironomus fluviatilis Lenz* | | | | | 15 | | | | |
| n | *Chironomus riparius Mg.* | | | | | 8 | | | | |
| t | *Cladotanytarsus mancus Walk.* | | | | | | | 11 | 19 | |
| h | *Conchapelopia pallidula Mg.* | | | | | 15 | | | | |
| i | *Cryptochironomus redekei Krus.* | | | | | 4 | | 4 | | |
| c | *Cryptotendipes anomalus K.* | | | | | 4 | 249 | | | |
| | *Demicryptochironomus vulneratus Zett.* | | 19 | | | | | | | |
| s | *Dicrotendipes nervosus Staeg.* | | | | | 4 | | | | |
| p | *Macropelopia nebulosa Mg.* | 4 | | | | | | | | 4 |
| e | *Micropsectra praecox Mg.* | | 4 | | | | | | | |
| c | *Micropsectra trivialis K.* | 23 | | | | | | | | |
| i | *Microtendipes chloris Mg.* | | | | | | 4 | | | |
| e | *Microtendipes pedellus de Geer* | | | | | | 15 | | | |
| s | *Paracladopelma camptolabis K.* | | | | | | 4 | | | 4 |
| | *Paratanytarsus lauterborni K.* | | | | 8 | | | | | |
| | *Pentapedilum sordens v. d. Wulp* | 34 | 11 | | 4 | | | | | |
| | *Polypedilum minutum Krug.* | 113 | 42 | | | 34 | | | 12 | |
| | *Polypedilum nubeculosum Mg.* | 634 | 8 | | | | | | | |
| | *Procladius choreus Mg.* | 23 | | | | 4 | 8 | | | |
| | *Protanypus morio Zett.* | | 8 | | | | | | | |
| | *Tanypus punctipennis Mg.* | | | | | 4 | 11 | | | |
| | *Tanytarsus arduensis Goetgh.* | | | | | | 4 | | | |
| | *Tanytarsus curticornis K.* | 4 | | | 4 | 4 | | | | |

**Table 10. (continued)**

| Species | Poiana | | Ştei | | Borz | Tinca | Zerind | | Sarkad |
|---|---|---|---|---|---|---|---|---|---|
| | bank | gravels | sandy sediment | gravels | gravels | sediment | sediment | phyto-tecton | clay sediment |
| *Tanytarsus gracillentus Holmgr.* | | | | | | 15 | | | |
| *Tanytarsus gregarius K.* | | 8 | | | 4 | | | | |
| *Thienemannimyia lentiginosa Fries* | 102 | 110 | | | | | | | |
| *Tripodura (Polypedilum) scalaenum Schr.* | | | | | 53 | | | | |
| *Trissopelopia longimana Staeg.* | 4 | | | | | | | | |
| Ind. density | 944 | 208 | 0 | 15 | 151 | 310 | 15 | 31 | 8 |
| Spe number | 10 | 8 | 0 | 3 | 12 | 8 | 2 | 2 | 2 |
| | | | | | | | | | |
| Total ind. | 1042 | 238 | 4 | 211 | 162 | 317 | 15 | 38 | 8 |
| Species richness | 14 | 13 | 1 | 12 | 14 | 10 | 2 | 3 | 2 |

**Table 11. Oligochaete and their quantity in the River Crişul Repede (Sebes Körös, in 1995)**

| | Sampling places | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Şaula | Ciucea | Bologa | Stâna de Vale | Vadul Crişului | Aleşd | Fughiu | Cheresig |
| Species | Ind./m$^2$ | | | | | | | |
| *Limnodrilus claparedeianus* | 328 | | | | 6 | | | 266 |
| *Limnodrilus hoffmeisteri* | 3443 | 56 | 561 | | | 12 | 17 | 5665 |
| *Limnodrilus profundicola* | 11 | | | | | | | |
| *Limnodrilus udekemianus* | 439 | | 27 | | | | | 54 |
| *Tubifex tubifex* | 859 | 6 | 53 | | 13 | 46 | 3 | 742 |

**Table 12. Chironomid fauna of the River Crişul Repede/Sebes Körös in 1995.**

| 1 | | | Spring area | | Aleşd | | | | Bologa | | | Downstream Ciucea | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | bank | main current | bank | 2 ms from the bank | bank | 26 ms from the bank | bank | 2 ms from the bank | main current | right bank | main current | left bank |
| 3 | | Species | Ind./m$^2$ | | | | | | | | | | | |
| 4 | P | *Cardiocladius fuscus K.* | | | | | | | | | | | | |
| 5 | h | *Cricotopus albiforceps K.* | | | | | | | | | | | | |
| 6 | y | *Cricotopus algarum K* | | 4 | 8 | 4 | | | | | | | | |
| 7 | t | *Cricotopus annulator Goetgh.* | | 8 | | | | | | | | | | |
| 8 | o | *Cricotopus bicinctus Mg.* | | | | | | | | | | | | |
| 9 | p | *Cricotopus fuscus K.* | | | | | | | | | | | | |
| 10 | h | *Cricotopus sylvestris Fabr.* | | | | | | | | | | | | |
| 11 | i | *Cricotopus tremulus Linnaeus* | | 8 | | | | | | | | | | |
| 12 | l | *Cricotopus trifasciatus Edw.* | 15 | 15 | | 8 | | | | | | | 4 | |
| 13 | e | *Eukiefferiella brevicalcar K.* | | | | | | | | | | | | |
| 14 | | *Eukiefferiella quadridentata Tshern.* | 19 | | | | | | | | | | | |
| 15 | s | *Eukiefferiella tshernovskii Pankr.* | 8 | | | | | | | | | | | |
| 16 | p | *Limnophies prolongatus K.* | | | | | | | | | 15 | | | |
| 17 | e | *Limnophies pusillus Eaton* | | 8 | | | | | | | | | | |
| 18 | c | *Metriocnemus hygropetricus K.* | | | 4 | | | | | | | | | |
| 19 | i | *Nanocladius bicolor Zett.* | | | | | | | | | | | | |
| 20 | e | *Orthocladius saxicola K.* | 11 | 90 | | 11 | | | | | | 4 | | |
| 21 | s | *Orthocladius thienemanni K.* | 23 | 4 | 11 | 38 | | 8 | | | | | | |
| 22 | | *Paracladius conversus Walk.* | | | | | | | | | | | | |
| 23 | | *Parakiefferiella bathophila K.* | | | | 5 | | | | | | | | |
| 24 | | *Potthastia gaedi Mg.* | | | | | | | | | | | | |
| 25 | | *Prodiamesa olivacea Mg.* | 4 | | | | | | | | | | | |

| 1 | | | Upstream Oşorhei | | | | | Fughiu | | Cheresig | | | | Szeg-halom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 ms from the bank | bank side | bank side | 6 ms from the bank | main current | 6 ms from the bank | 2 ms from the bank | bank side | main current | bank side | 2 ms from the bank | main current | main current | 2 ms from the bank |
| 3 | | | | | | | | | | | | | | |
| 4 | | | | | | | 0 | | 15 | | | | | |
| 5 | | | | | | | 4 | | | | | | | |
| 6 | | | | | | | 4 | | | 8 | | | | |
| 7 | | | | | | | | | | | | | | |
| 8 | | 11 | | | | | | | | | | | | |
| 9 | | | | | | | 8 | | | | | | | |
| 10 | | | | | | | 4 | | | | | | | |
| 11 | | | | | | | | | | | | | | |
| 12 | | | | | | | 26 | | | | | | | |
| 13 | | 8 | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | |
| 19 | | | | | 4 | | 4 | | 4 | | | | | |
| 20 | 4 | 11 | 8 | | 4 | | 11 | | 19 | | | | 19 | |
| 21 | 11 | | | 4 | | | 15 | 8 | | | | 11 | | |
| 22 | | | | | | | | | 83 | | | | | |
| 23 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | 26 | | | | | |
| 25 | | | | | | | | 79 | | | | | | |

**Table 12.(continued)**

| 1 | | | Spring area | | Aleşd | | | | Bologa | | | Downstream Ciucea | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | bank | main current | bank | 2 ms from the bank | bank | 26 ms from the bank | bank | 2 ms from the bank | main current | right bank | main current | left bank |
| 3 | | Species | Ind./m² | | | | | | | | | | | |
| 26 | | *Psectrocladius barbimanus Edw.* | | | | | | | | 4 | | | | |
| 27 | | *Psectrocladius dilatatus v. d. Wulp* | 125 | | | 4 | | | | | | | | |
| 28 | | *Symposiocladius lignicola K.* | | | | | | | | | | | | |
| 29 | | *Thienemanniella vittata Edw.* | | | | | | | | | | | | |
| 30 | | *Trissocladius fluviatilis Goetgh.* | | | | | | | | | 38 | | | |
| 31 | | Ind. density | 204 | 136 | 23 | 69 | 0 | 8 | 0 | 4 | 53 | 4 | 4 | 0 |
| 32 | | Species number | 7 | 7 | 3 | 6 | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 0 |
| 33 | | | | | | | | | | | | | | |
| 34 | B | *Apsectrotanypus trifascipennis Zett.* | | | | | | | | | | | | |
| 35 | e | *Chironomus (fluviatilis Lenz) thummi* | | | | | | | | | | | | |
| 36 | n | *Chironomus riparius Mg.* | | | | | | | | | | | | 4 |
| 37 | t | *Cladopelma laccophila K.* | | | | | | | | | | | | |
| 38 | h | *Cladotanytarsus mancus Walk.* | | | 155 | | 465 | 41 | | | | 4 | | 4 |
| 39 | i | *Clinotanypus nervosus Mg.* | | | | | | | | | | | | |
| 40 | c | *Corynoneura celeripes Win.* | 8 | | | | | | | | | | | |
| 41 | | *Corynoneura lemnae Frauenfeld* | | | | | | | | | | | | |
| 42 | s | *Cryptochironomus redekei Krus.* | | | 38 | | 72 | 15 | | | | | 4 | 4 |
| 43 | p | *Cryptotendipes anomalus K.* | | | | | | | | | | | | |
| 44 | e | *Demicryptochironomus vulneratus Zett.* | | | | | | | | | 11 | | | |
| 45 | c | *Dicrotendipes nervosus Staeg.* | | | | | | | | | | | | |
| 46 | i | *Dicrotendipes tritomus K.* | | | | | | | | | | | | |
| 47 | e | *Einfeldia pectoralis K.* | | | | | | | | | | | | 4 |
| 48 | s | *Glyptotendipes cauliginellus* | | | 4 | | | | | | | | | |

| 1 | | | Upstream Oşorhei | | | | | Fughiu | | Cheresig | | | | Szeg-halom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 ms from the bank | bank side | bank side | 6 ms from the bank | main current | 6 ms from the bank | 2 ms from the bank | bank side | main current | bank side | 2 ms from the bank | main current | main current | 2 ms from the bank |
| 3 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 27 | | | | | | | | 4 | 4 | | | 8 | | |
| 28 | | | | | | | | | 15 | | | | | |
| 29 | | | 4 | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | |
| 31 | 15 | 30 | 11 | 4 | 8 | 0 | 76 | 91 | 166 | 8 | 0 | 19 | 19 | 0 |
| 32 | 2 | 3 | 2 | 1 | 2 | 0 | 9 | 3 | 7 | 1 | 0 | 2 | 1 | 0 |
| 33 | | | | | | | | | | | | | | |
| 34 | | | | | | | 15 | | | | | | | |
| 35 | | | | 23 | | | 140 | 8 | | | | 4 | | |
| 36 | | | | | | | 8 | 15 | | | | | | |
| 37 | | | | | | | | | | | | | | 4 |
| 38 | | 8 | 4 | 4 | | 4 | 26 | | | | | | 34 | |
| 39 | | | | | 4 | | | | | | | | | |
| 40 | | | | | | | | | | | | | | |
| 41 | | | | | | | | 4 | | | | | | |
| 42 | | | | 8 | 11 | | 15 | 4 | | | 45 | 23 | 49 | |
| 43 | | | 4 | | | | | | | | | 4 | | |
| 44 | | | | | | | | | | | | | | |
| 45 | | | | | | | 11 | | 11 | | | 8 | 72 | |
| 46 | | | 8 | 11 | | | 125 | | | | 4 | 4 | | |
| 47 | | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | | |

**Table 12.(continued)**

| 1 | | | Spring area | | Aleşd | | | | Bologa | | | Downstream Ciucea | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | bank | main current | bank | 2 ms from the bank | bank | 26 ms from the bank | bank | 2 ms from the bank | main current | right bank | main current | left bank |
| 3 | | Species | Ind./$m^2$ | | | | | | | | | | | |
| 49 | | *Kiefferulus tendipediformis Goetgh.* | | | | | | | | | | | | |
| 50 | | *Lenzia flavipes Mg.* | | | | | | | | | | | | |
| 51 | | *Paracladopelma camptolabis K.* | | | 8 | | 11 | | | | | | | |
| 52 | | *Paracladopelma rolli Kirp.* | | | | | | | | | | | | |
| 53 | | *Macropelopia nebulosa Mg.* | | | | | | | | | | | | |
| 54 | | *Micropsectra praecox Mg.* | | | | 4 | | | | | 8 | | | |
| 55 | | *Microtendipes chloris Mg.* | | | | | | | | | | | | 8 |
| 56 | | *Parachironomus arcuatus Goetgh.* | | | | | | | | | | | | |
| 57 | | *Paratendipes intermedius Tsh.* | | | | | | | | | | | | 4 |
| 58 | | *Patatendipes connenctens Lipina* | | | | | | | | | | | | 4 |
| 59 | | *Pentapedilum sordens v. d. Wulp* | 4 | | 11 | 8 | | | | | | | 15 | |
| 60 | | *Polypedilum minutum Krug.* | | | | | | | | | | | 4 | |
| 61 | | *Polypedilum nubeculosum Mg.* | | | 4 | | 8 | | | | | | | |
| 62 | | *Polypedilum scalaenum Schr.* | 26 | 4 | | | | 4 | | | | 4 | 4 | 196 |
| 63 | | *Procladius choreus Mg.* | | | 11 | | 26 | | | | | | | |
| 64 | | *Procladius conversus Walk.* | | | | | | | | | | | | |
| 65 | | *Camptochironomus tentans Fabr.* | | | | | | | | | | | | |
| 66 | | *Thienemannimyia lentiginosa Fries* | | | | | | | | 4 | 4 | | 11 | |
| 67 | | *Tanypus punctipennis Mg.* | | | | | 4 | | | | | | | |
| 68 | | *Tanytarsus curticornis K.* | | | | | | | | | | | | |

| 1 | | | Upstream Oşorhei | | | | | Fughiu | | Cheresig | | | | Szeg-halom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 ms from the bank | bank side | bank side | 6 ms from the bank | main current | 6 ms from the bank | 2 ms from the bank | bank side | main current | bank side | 2 ms from the bank | main current | main current | 2 ms from the bank |
| 3 | | | | | | | | | | | | | | |
| 49 | | | | | | | 4 | | | | | | | |
| 50 | | | | 4 | | | | | | | | | | |
| 51 | | | | 4 | | | 4 | | | | | 8 | | |
| 52 | | | | | | | | | | | | | | 8 |
| 53 | | | | | | 4 | 30 | 15 | | | | | | |
| 54 | 4 | | | 11 | | | | 19 | 4 | 4 | | 4 | 4 | |
| 55 | | 4 | | | | | | 11 | | | | | | |
| 56 | | | | | | | | 4 | | | | | | |
| 57 | | | 4 | 4 | | | | 19 | | | | | | |
| 58 | | | | | | | | | | | | | | |
| 59 | 11 | 19 | | | | | | 30 | 8 | | | | | |
| 60 | 4 | 4 | | 4 | | 4 | 4 | 4 | | | | | | |
| 61 | | | 4 | | | | 15 | 4 | | | | 4 | 8 | 4 |
| 62 | 15 | 11 | 8 | 64 | 8 | | 45 | 98 | | 83 | 242 | 128 | 491 | 30 |
| 63 | | | 8 | | | | | 4 | | | | | | |
| 64 | | | | | | | 4 | | | | | | | |
| 65 | | | | 4 | | | | | | | | | | |
| 66 | | 8 | 4 | | | 4 | | 4 | | 4 | | 4 | | |
| 67 | | | | | | | | | | | | | | |
| 68 | | | 4 | | | | | | | | | 8 | 4 | |

**Table 12.(continued)**

| 1 | | | Spring area | | Aleşd | | | | Bologa | | | Downstream Ciucea | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | bank | main current | bank | 2 ms from the bank | bank | 26 ms from the bank | bank | 2 ms from the bank | main current | right bank | main current | left bank |
| 3 | | Species | Ind./$m^2$ | | | | | | | | | | | |
| 69 | | *Tanytarsus gracillentus Holmgr.* | 19 | | | | | | | | | | | |
| 70 | | *Tanytarsus gregarius K.* | | | | | | | | 4 | | | | |
| 71 | | Ind. density | 57 | 4 | 230 | 12 | 585 | 60 | 0 | 8 | 23 | 8 | 38 | 227 |
| 72 | | Species number | 4 | 1 | 7 | 2 | 6 | 3 | 0 | 2 | 3 | 2 | 5 | 8 |
| 73 | | | | | | | | | | | | | | |
| 74 | | Total ind./$m^2$ | 261 | 139 | 253 | 81 | 585 | 68 | 0 | 11 | 76 | 11 | 42 | 227 |
| 75 | | Species richness | 11 | 8 | 10 | 8 | 6 | 4 | 0 | 3 | 5 | 3 | 6 | 8 |

| 1 | | | Upstream Oşorhei | | | | | Fughi u | | Cheresig | | | | Szeg-halom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 ms from the bank | bank side | bank side | 6 ms from the bank | main current | 6 ms from the bank | 2 ms from the bank | bank side | main current | bank side | 2 ms from the bank | main current | main current | 2 ms from the bank |
| 3 | | | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | | | |
| 70 | 4 | 42 | | 4 | | | 15 | | 19 | | | | | |
| 71 | 38 | 94 | 45 | 144 | 23 | 15 | 461 | 242 | 42 | 91 | 291 | 196 | 661 | 45 |
| 72 | 5 | 7 | 9 | 12 | 3 | 4 | 13 | 14 | 4 | 3 | 3 | 11 | 7 | 4 |
| 73 | | | | | | | | | | | | | | |
| 74 | 53 | 125 | 57 | 147 | 30 | 15 | 536 | 332 | 208 | 98 | 291 | 215 | 680 | 45 |
| 75 | 7 | 10 | 11 | 13 | 5 | 4 | 22 | 17 | 11 | 4 | 3 | 13 | 8 | 4 |

Table 13. The macrozoobenthos in River Bodrog and its tributaries (2-16 August, 1999)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | | Ung | Ung | Ung | Ung | Ung | Ung | Ung |
| 2 | Sampling sites | 1. Storozhnica | | 2. Nevickeupstr. | Nevicke upstr. | Nevicke upstr. | 3. Uzhok | 3/a |
| 3 | Species | stagnant w. | current w. | the main current | mudy | near bank | spring area | Stavne upstr. |
| 4 | | | | Individuals in samples | | | | |
| 5 | *Chironomus anthracinus (gr.)* | | | | | | | |
| 6 | *Chironomus riparius (Meigen 1804)* | 5 | | | 15 | | | |
| 7 | *Chironomus lacunarius (Wülker 1973)* | | | | 2 | | | |
| 8 | *Chironomus aprilinus (Meigen 1830)* | | 1 | | | | | |
| 9 | *Cryptochironomus defectus (Kieffer 1913)* | 2 | | | 1 | 1 | | |
| 10 | *Cryptochironomus redekei (Kruseman 1933)* | 2 | | | | | | |
| 11 | *Glyptotendipes pallens (Meigen 1804)* | 1 | | | | | | |
| 12 | *Demicryptochironomu s vulneratus (Zetterstedt 1838)* | | | | | | | 1 |
| 13 | *Einfeldia carbonaria (Meigen 1804)* | | 1 | | | | | |
| 14 | *Endochironomus tendens (Fabricius 1775)* | | | | | | | |
| 15 | *Microtendipes chloris (Meigen 1818)* | 1 | | | | 1 | | |
| 16 | *Cladotanytarsus mancus (Walker 1856)* | | | 3 | | | | |
| 17 | *Constempellina brevicosta (Edwards 1937)* | | | | | | | |
| 18 | *Micropsectra atrofasciata (Kieffer 1911)* | | | | | | | |
| 19 | *Micropsectra junci (Meigen 1818)* | | 1 | | | | | |
| 20 | *Rheotanytarsus curtistylus (Goetghebuer 1921)* | | 1 | | | 1 | | |
| 21 | *Tanytarsus gregarius (Kieffer 1909)* | 2 | | 2 | | 1 | | |
| 22 | *Tanytarsus gregarius (Kieffer 1913)* | | | | | | | |
| 23 | *Dicrotendipes nervosus (Staeger 1838)* | 1 | 14 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Latorca | Latorca | Latorca | Ung | Latorca | Laborec | Laborec | Laborec |
| 2 | 4. Pidpolozja | 5. Pasika | 6. Chop upstr. | 7. Pavlovce | 8. Velk. Kap. | 9. Certizne upstr. | 9/a Koskowce downstr. | 10. Petrovce downstr. |
| 3 | the main current | | | | | spring area | | |
| 4 | | | | | | | | |
| 5 | | | | | | 1 | | |
| 6 | | | | 18 | 12 | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | 1 | | | | | | |
| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | 8 | | | | | | 2 |
| 18 | 2 | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | 11 | |
| 21 | 4 | 2 | | | | | | |
| 22 | | | | | | 1 | | |
| 23 | | | | | | | 4 | |

**Table 13. (continued)**

| 1 | | Ung | Ung | Ung | Ung | Ung | Ung | Ung |
|---|---|---|---|---|---|---|---|---|
| 2 | Sampling sites | 1. Storozhnica | | 2. Nevickeupstr. | Nevicke upstr. | Nevicke upstr. | 3. Uzhok | 3/a |
| 3 | Species | stagnant w. | current w. | the main current | mudy | near bank | spring area | Stavne upstr. |
| 4 | | | | Individuals in samples | | | | |
| 24 | *Dicrotendipes tritomus (Kieffer 1916)* | | 5 | | | | | |
| 25 | *Parachironomus arcuatus (Goetghebuer 1919)* | | | | | | | |
| 26 | *Paracladopelma nigritula (Goetghebuer 1942)* | | | | | 1 | | |
| 27 | *Paralauterborniella nigrohalteralis (Malloch 1915)* | | | | 3 | | | |
| 28 | *Polypedilum convictum (Walker 1856)* | | | | | | | |
| 29 | *Polypedilum laetum (Meigen 1818)* | | | | | | | 2 |
| 30 | *Polypedilum nubifer (Skuse 1889)* | | | | | | | |
| 31 | *Tripodura scalaenum (Schrank 1803)* | 5 | | | | 1 | | 1 |
| 32 | *Pentapedilum sordens (van d. Wulp 1874)* | | | | | | | 1 |
| 33 | *Sergentia longiventris (Kieffer 1924)* | | | 1 | | | | |
| **34** | **Ephemeroptera** | | | | | | | |
| 35 | *Baëtis pumilus (Burmeister 1839)* | | | | | | | |
| **36** | **Plecoptera** | | | | | | | |
| 37 | *Perlodes microcephalus (Pictet 1833)* | | | 1 | | | | 1 |
| 38 | *Perla sp.* | | | | | | | |
| **39** | **Species no.** | **13** | **13** | **8** | **9** | **10** | | **14** |

| 1 | Latorca | Latorca | Latorca | Ung | Latorca | Laborec | Laborec | Laborec |
|---|---|---|---|---|---|---|---|---|
| 2 | 4. Pidpolozja | 5. Pasika | 6. Chop upstr. | 7. Pavlovce | 8. Velk. Kap. | 9. Certizne upstr. | 9/a Koskowce downstr. | 10. Petrovce downstr. |
| 3 | the main current | | | | | spring area | | |
| **4** | | | | | | | | |
| 24 | | | | | | | | |
| 25 | | | | | | 2 | | |
| 26 | | | | | | | | |
| 27 | | | | | | 2 | | |
| 28 | | 1 | | | | 2 | | 3 |
| 29 | 1 | 4 | | | | | 2 | |
| 30 | | | | 12 | | | | 1 |
| 31 | | | | | | | | |
| 32 | | 28 | | | | 4 | | |
| 33 | | | | | | | | |
| **34** | | | | | | | | |
| 35 | | 2 | | | | | | |
| **36** | | | | | | | | |
| 37 | | | | | | | 3 | |
| 38 | | | | | | 1 | | |
| **39** | **6** | **13** | **0** | **2** | **2** | **11** | **10** | **6** |

Table 14. The macrozoobenthos in River Bodrog and its tributaries between August 2-16, 1999

| Species | Laborec<br>11. Stretawka down-stream | Latorca<br>12. Zatin | Bodrog<br>13. Vinicky | Ondava<br>14. Nizny Milosow | Ondava<br>15. Cicava | Ondava<br>16. Horovce | Ondava tork. vid.<br>17. Brehov | Bodrog<br>18. Felső-berecki | Bod-rog<br>19. B. olaszi | Bodrog<br>20. Bodrog-keresztúr |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | spring area | | | | | | |
| **Oligochaeta** | Individuals in samples | | | | | | | | | |
| *Branchiura sowerbyi (Beddard 1892)* | | | 1 | | | | | | | |
| *Limnodrilus hoffmesiteri (Claparéde 1862)* | 8 | 6 | 13 | | | | | | 5 | 1 |
| *Tubifex nevaensis (Michaelsen 1903)* | 8 | | | | | | | | | |
| **Chironomidae** | | | | | | | | | | |
| **Tanypodinae** | | | | | | | | | | |
| *Anatopynia plumipes (Fries 1823)* | | | 6 | | | | | | | |
| *Apsectrotanypus trifascipennis (Zetterstedt 1838)* | | | | 12 | | | | | | |
| *Procladius choreus (Meigen 1804)* | | | | | | | | | | 1 |
| **Orthocladiinae** | | | | | | | | | | |
| *Cricotopus bicinctus (Meigen 1818)* | | | | 3 | | | | | | 1 |
| *Cricotopus flavocinctus (Kieffer 1924)* | | | | | | 2 | | | | |
| *Eukiefferiella brevicalcar (Kieffer 1911)* | | | | 2 | | 1 | | | | |
| *Eukiefferiella clypeata(Kieffer 1923)* | | | | 8 | | | | | | |
| *Prodiamesa olivacea (Meigen 1818)* | | | | | 1 | | | | | |
| *Rheocricotopus effusus (Walker 1856)* | | | | 4 | | | | | | |
| **Chironomini** | | | | | | | | | | |
| *Chironomus riparius (Meigen 1804)* | 12 | 8 | 7 | | | | | | | |
| *Paracladopelma camptolabis (Kieffer 1913)* | | | 1 | | | | | | | |

**Table 14. (continued)**

| Species | Laborec<br>11. Stretawka down-stream | Latorca<br>12. Zatin | Bodrog<br>13. Vinicky | Ondava<br>14. Nizny Milosow<br>spring area | Ondava<br>15. Cicava | Ondava<br>16. Horovce | Ondava tork. vid.<br>17. Brehov | Bodrog<br>18. Felső-berecki | Bod-rog<br>19. B. olaszi | Bodrog<br>20. Bodrog-keresztúr |
|---|---|---|---|---|---|---|---|---|---|---|
| *Paralauterborniella nigrohalteralis (Malloch 1915)* | | | | | | | | | | 2 |
| *Pentapedilum sordens (van d. Wulp 1874)* | | | | 22 | 1 | 1 | | | | |
| *Polypedilum convictum (Walker 1856)* | | 4 | | | | | | | | |
| *Polypedilum nubifer (Skuse 1889)* | 6 | 4 | | | | | | | | |
| *Tripodura scalaenum (Schrank 1803)* | | | 1 | 2 | 1 | 17 | | | | |
| **Tanytarsini** | | | | | | | | | | |
| *Tanytarsus gregarius (Kieffer 1909)* | | | | | | 3 | | | | |
| **Amphipoda** | | | | | | | | | | |
| *Dikerogammarus haemobaphes fluviatilis (Martinov 1919)* | | | | | 34 | 2 | | | | |
| **Odonata** | | | | | | | | | | |
| *Gomphus flavipes (Charpentier 1825)* | | | | | 1 | | 1 | | | |
| **Ephemeroptera** | | | | | | | | | | |
| *Baëtis pumilus (Burmeister 1839)* | | | | 10 | | | | | | |
| *Cloëon dipterum (Linnaeus 1761)* | | | 2 | | | 1 | | | | |
| *Habrophlebia fusca (Curtis 1831)* | | | | | 4 | | | | | |
| **Culicidae** | | | | | | | | | | |
| *Chaoborus crystallinus (De Geer 1776)* | | | 7 | | | | | | | |
| **Species richness** | 4 | 4 | 8 | 8 | 6 | 7 | 1 | 0 | 1 | 4 |

**References**

Ashe, P., Cranston, P. S., 1990: Chironomidae. In: Soós (ed.) Catalogue of Palaearctic Diptera. *Akadémiai Kiadó, Budapest, 1 13-441.*

Bíró, K., 1981: Az árvaszúnyoglárvák (Chironomidae) kishatározója. In: *Felföldy (szerk.) VHB 11:1-230, VÍZDOK, Bp..*

Csernovszkij, A. A., 1949: Opredelitel licsinok komarov szemejsztva Tendipedidae. Opredeliteli po faune SZSZSZR. - *Izd. Akad. Nauk SZSZSZR., Leningrád, 31: 1-185 (oroszul).*

Delong, M. D; Brusven, M. A., 1998: Macroinvertebrate community structure along the longitudinal gradient of an agriculturally impacted stream. - *Environ. Manage., 22, 3: 445-457.*

Dratnal, E.; Kasprzak, K., 1980: The Response of the Invertebrate Fauna to Organic Pollution in a Well Oxygenated Karst Stream Exemplified by the Pradnik Stream (South Poland) . – *Acta Hydrobiologica, 22, 3: 263-278.*

Ferencz, M., 1979: A vízi kevéssertéjű gyűrűsférgek (Oligochaeta) kishatározója. - In: *Felföldy (szerk.) VHB 7: 1-170, VÍZDOK, Bp..*

Fittkau, E. J., 1962: Die Tanypodinae (Diptera, Chironomidae). - *Abhandlungen zur Larvensystematik der Insekten, No.6: 1-453.*

Fittkau, E. J., Roback, S. S., 1983: 5. The larvae of Tanypodinae (Diptera: Chironomidae) of the Holactic region - Keys and diagnoses. - *Ent. Scand. Suppl., 19: 33- 110.*

Hirvenoja, M., 1973: Revision der Gattung Cricotopus van der Wulp und ihrer vervandten (Diptera: Chironomidae). - *Ann. Zool. Fenn., 10: 1-163.*

Hynes, H. B.N; Harrison, A. D; Berhe, T., 1989: Degradation of a Stream Crossing the City of Addis Ababa, Ethiopia. – *Tropical Freshwater Biology, 2, 1: 112-120.*

Nuttall P. M., Purves, J. B., 1974: Numerical Incides applied to the Results of a Survey of the Macroinvertebrate Fauna of the Tamar Catchment (Southwest England). – *Freshw. Biology, 4, 3: 213-222.*

Olive, J, H; Smith, K. R., 1975: Benthic Macroinvertebrates as Indexes of Water Quality in the Scioto River Basin, Ohio. - *Bulletin of the Ohio Biological Survey, New Series, 5, 2: 124.*

Pinder L.C.V. & Reiss, F., 1983: 10. The larvae of Chironominae (Diptera: Chironomidae) of the Holoarctic Region. - Keys and diagnoses. - *Ent. Scand. Suppl. 19: 293-435.*

Ruse, L. P; Herrmann, S. J; Sublette, J. E., 2000: Chironomidae (Diptera) species distribution related to environmental characteristics of the metal-polluted Arkansas. - *West. N. Am. Nat., 60, 1: 34-56.*

Schofield, K; Whitelaw, K; Merriman, R. P., 1989: The Impact of Farm Pollution on River Quality in the United Kingdom . – River Basin Management--V. Advances in Water Pollution Control: A Series of Conferences Sponsored by the IAWPRC. - *Pergamon Press, Inc., New York, 219-228.*

Szító, A., 1981: Environmental factors influencing the abundance of Chironomid larvae. - *Tiscia (Szeged) XVI: 191-203.*

Szító, A., 1995: Macrozoobenthos in the Maros (Mureş) River. – In: Hamar, J. and Sárkány, K. E., (eds.): The Maros/Mureş River Valley. – TISCIA monograph series, 185-191.

Szító, A., 1998a: Üledékfauna, fajok, élőhely minősítés. - *Hidrológiai Közlöny, 78, 5-6: 320-322.*

Szító, A., 1998b:A Lovasi - séd, a Csopaki - séd és a Koloska patak árvaszúnyog faunájának szezonális dinamikája, biomasszája és diverzitás értékei. - *Hidrológiai Közlöny, 78, 5-6: 323-324.*

Szító, A., 1999: The Oligochaete and the Chironomid fauna of the Upper Tisa Region and its tributaries. – In: Hamar, J. and Sárkány-Kiss, A. (eds.): The Upper Tisa Valley. - *TISCIA monograph series, 401-407.*

Szító, A., 2000a: Az Örvényesi-, az Aszófői-, és a Szőlősi séd árvaszúnyog faunája, biomasszája és diverzitás értékei. - *Hidrológiai Közlöny 80, 1: 1: 41-44.*

Szító, A., 2000b: Az Egervíz, a Tapolca- és a Burnót patak Oligochaeta és Chironomida faunája. - *Hidrológiai Közlöny 80, 5-6: 388-390.*

Szító, A., 2000c: The macrozoobenthos of the River Bodrog Region and its tributaries. – in: Gallé, L. and Körmöczi, L. (eds.): Ecology of River Valleys. - *TISCIA monograph series, Univ. Szeged, 189-195.*

Szító, A., and Mózes Katalin, 1997: The Oligochaeta and the Chironomid fauna as pollution indicators in the Criş/Körös river system. - In: Sárkány-Kiss, A. and Hamar, J. (eds.): The Criş/Körös Rivers' Valleys. A study of the geography, hydrobiology and ecology of the river system and its environment. - *TISCIA monograph series, 165-194.*

Szító, A., and Mózes, K., 1999: The Oligochaeta and the Chironomid fauna in the Someş/Szamos River system. - In: Sárkány-Kiss, A. and Hamar, J. (eds.): The Someş/Szamos Rivers' Valleys. A study of the geography, hydrobiology and ecology of the river system and its environment. - *TISCIA monograph series, 179-191.*

Waterhouse, J. C; Farrell, M. P., 1985: Identifying Pollution Related Changes in Chironomid Communities as a Function of Taxonomic Rank. - *Canadian Journal of Fisheries and Aquatic Sciences, 42, 3: 406-413.*

SZÍTÓ A.
Institute for Fisheries
Aquaculture and Irrigation, Szarvas
Anna-liget 8., H-5540 Szarvas
Hungary

# THE PRESENT STATUS OF THREAT TO THE CADDIS FLIES (TRICHOPTERA) FROM THE RIVERS ŞOMEŞ, MUREŞ AND CRIŞURI CATCHMENT AREA IN ROMANIA

*Ujvárosi Lujza*

**Abstract**

The distribution of Trichoptera was analysed at 31 sampling sites distributed along different water courses, tributaries of the rivers Someş, Mureş and the three Crişuri, in order to determine characteristic associations of caddis flies species in the different sectors of these rivers. Beside the personal observations, the author's aim is to summarize most of the published information, as well as results of personal collecting data concerning caddis fly taxa which are vulnerable, endangered or already destroyed by human activities, with notes on altered, endangered or vulnerable habitats of Trichoptera from these catchment areas. Altogether 193 species of caddis flies have been observed since 1898 along rivers. A number of 11 species have become extinct in the area investigated, mostly from the large rivers and eutrophic or oligotrophic pools, in the catchments area. The other 184 species can be categorized into five groups on the basis of their conservation status: unknown (or insufficiently known), endangered, vulnerable, presumed vulnerable and not threatened. The unknown (or insufficiently known) are those that have been collected before the nineties, the recent studies do not confirm their presence in the area investigated, but they could be still present. Their habitat must be studied in the future. The endangered species have a few, small and isolated populations, most of the endemic and relict species also belong to this group. Most of the endangered species are living in sources, mountainous brooks and hilly streams.

The situation of the threatened caddis flies can differ from a river system to an other. The number of species dwelling in the springs and brooks in the mountainous and sub mountainous area is still very high. The caddis fly community of the lower sector of these rivers is rather poor and uniform in relation with the sectors in the mountainous and hilly areas, with species having wide ecological tolerance. Probably a certain improvement of the water quality of these rivers is responsible for this.

**Keywords:** Trichoptera, faunistical list, Someş, Mureş, Crişuri river systems, endangered species, extinction, conservation

## Introduction

The presence or absence of organisms is related to biotic and abiotic factors. The repeatability of these relationships can be used for marking water typologies and water quality assessments. Organisms and communities, like caddis flies, function in this way as bioindicators. Mereover, human activities have their impact on streams and rivers, causing changes in the original circumstances. Under the new conditions, alterations in the composition of the community are observed, and here again organisms can act as bio-indicators of the new situation or maybe even of the alteration (HIGLER and TOLKAMP, 1982). This required a long term study of the water bodies, and a comparison of the published data with the personal observations is also necessary for underline the evolution trends of the community and the possibility of restauration of the endangered or distroyed habitats.

The main tributaries of Tisa in Romania are the rivers Someş, Mureş and the three Crişuri, with a cathcment area which covers almost the whole Transylvania, divided in mountainous, hilly and lowland sectors. These three rivers receive numerous tributaries in the catchment area (UJVARI, 1972).

The Someş river system has a total surface of the catchment area of 15 217 km, and is found in the northern part of the Transylvanian basin, the origins of the water courses wich form the spring sector are in the Apuseni, Gutâi, Ţibles, Rodnei, Bârgăului and Călimani Mountains. The largest tributaries are Someşul Mare and Someşul Mic.

The three Crişuri rivers and its tributaries come from the northern, western and southern part of the Apuseni Mountains, the whole river system has a surface of 14 880 km in Romania. The largest tributaries are the Ierul, Barcăul, Crişul Repede, Crişul Negru and Crişul Alb.

The Mureş river system spreads over on a surface of 27 919 km in Romania. The majority of the tributaries came from the Eastern and Southern Carpathians and from the Apuseni Mountains. The largest tributaries are: Târnava Mică, Târnava Mare, Luduş and Arieş.

The total number of the Romanian caddis fly species is uncertain. CIUBUC (1993) listed 267 caddis flies. In addition BOTOŞĂNEANU (1993) cited other 12 species new to the country fauna, two years later (1995) the same author published important new data and commented on the presence and absence of a number of species, previously cited from Romania. Based on the last few years' intensive investigations, made by the author mainly along the mountains brook on the Eastern Carpathians, other six new species for the country's fauna have been recorded (UJVÁROSI, 1995, 1997, 1998, UJVÁROSI, NÓGRÁDI, 1999).

Up to the present a number of 193 species of caddis flies have been recorded from the Romanian section of the rivers Someş, Mureş and Crişuri catchment area, wich represent about 65-70 % of the whole Romanian fauna.

## Material and methods

Adults of trichoptera were sampled along the rivers Someş, Mureş and the three Crişuri and their tributaries. Three customary collecting methods were applied in our fieldwork, between 1994-2000. Daytime sweeping resulted in a small material, but a few species were collected only by this way. Night personal collecting ("lighting") was usually very fruitful. We always used mercury-vapor bulbs (160 or 250 Watts). These lamps were powered by a portable generator (Honda EM650 or EG550 types). In addition in 1994 and 2000 two light traps were operated, one in Floreşti, near the left side of the river Someşul Mic, tributary of Someş and another near the Valea Ierii village, in the Iara Valley, along the Iara brook, a small tributary of Mureş from the Apuseni Mountains. We did not collect and study immature stages as they are rather unsatisfactorily known, especially in the case of the rare and endemic species.

A number of 129 species were collected and examined, wich represent 66,83 % from the total number of species recorded from this area.

## Sampling sites

The sampling sites, situated mostly along the tributaries of the rivers mentioned above, were located at different altitudes (from 110 to 1400 m.a.s.l). The collecting sites are presented according to the following list (Fig. 1):

River Someş catchment area:

S1. Arcalia, Şieu stream, tributary of Someşul Mare river, 330 m
S2. Cluj town, Someşul Mic, 340 m
S3. Floreşti, Someşul Mic river, 350 m
S4. Chinteni, artificial ponds and channels, 380 m
S5. Doda Pilii, Someşul Cald river, 940 m
S6. Ic Ponor, Someşul Cald river downstream to the gorge, 950 m
S7. Cheile Someşului Cald, 1070 m
S8. Cetatea Rădesii, a natural cave in the spring sector of the Someşul Cald river, 1100 m

River Mureş catchment area:

M1. Reghin town, 390 m
M2. Rimetea, Piatra Secuiului, springs in rocks, Arieş catchments area, 400 m
M3. Tureni, Tureni gorge, Turului stream, Arieş catchments area, 410 m
M4. Subcetate, Târnava Mare river, 465 m
M5. Răstoliţa, brooks near Mureş river, 490 m
M6. Androneasa, near Mureş, 500 m
M7. Poruţ, Iara stream, 500 m

M8. Poşaga de Sus, Scăriţa Belioara Nature Reserve Area, Arieş catchments area, 520 m

M9. Praid, Târnava Mică river, 550 m

M10. Valea Ierii, Iara river, Arieş catchments area, 570 m

M11. Remetea, Gheorgheni Depression, 730 m

M12 Voşlobeni, Senetea, eutrophic pools and moors near Mureş, 780 m

M13 Retezat, Gura Zlata, mountainous brooks, 800 m

M14 Arieşeni, springs systems on the source of the Arieş river, 840 m

M15 Băişoara, mountainous springs at 1385 m

River Crişuri catchment area:

C1 Cefa, fischery ponds, 110 m

C2 Vadul Crişului, Crişul Repede gorge, 260 m

C3 Aciuţa, Crişul Alb river catchment area, 300 m

C4 Avram Iancu, Crişul Negru river catchments area, 330 m

C5 Valea Drăganului, Drăgan stream, tributary of Crişul Repede, 400 m

C6 Valea Iadului, mountainous brooks at 420 m

C7 Blăjeni, Crişul Alb river, 470 m

C8 Vlădeasa, springs and brooks in spruce fir forest, 1400 m

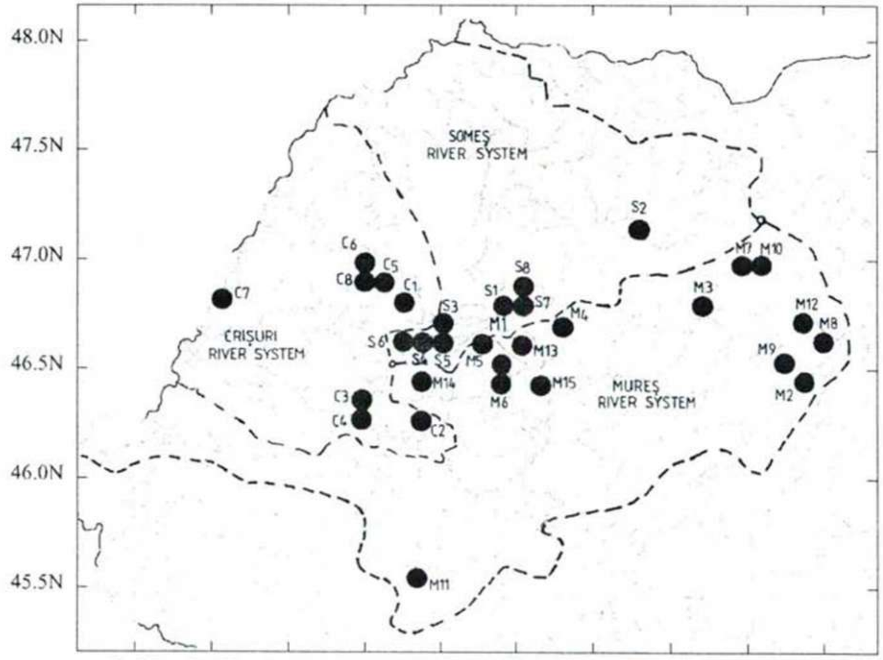



*Fig. 1.* **Sampling sites in the area investigated (explications see in the text).**

## Results and discussion

The total number of trichoptera species is 193, from which a number of 129 species result from personal investigations. A number of 31 collecting sites was studied. A number of 9 trichoptera species are recorded for the first time from this area: *Allotrichi pallicornis, Tinodes kimminsi, Limnephilus flavospinosus, Limnephilus incisus, Anabolia furcata, Annitella obscurata, Lithax obscurus, Oecetis notata, O. testacea*. The presence of another species have not been confirmed during our investigations. These species are: *Rhyacophila furcifera, R. philopotamoides, Synagapetus armatus, S. iridipennis, Agapetus fuscipes, A. rectigonopoda, Stactobia maclachlani, Ortotrichia angustella, Hydroptila sparsa, Wormaldia subnigra, Hydropsyche botosaneanui, H. bulgaromanorum, H. ornatula, H. tabacarui, Polycentropus excisus, Holocentropus picicornis, Lipe phaeopa, Tinodes rostocki, Trichostegia minor, Phryganea bipunctata, P. grandis, Oligotricha striata, Oligostomis reticulata, Brachicentrus montanus, Oligoplectrum maculatum, Apatania carpathica, Drusus biguttatus, D. buscathensis, Drusus trifidus, Limnephilus binotatus, L. fuscicornis, Grammotaulius nitidus, Glyphotaelius pellucidus, Phacopteryx brevipennis, Potamophylax milleni, Chionophylax mindszentyi, Melampophylax polonicus gutinicus, Isogamus aequalis, Anisogamus difformis, Micropterna sequax, Chaetopteryx polonica, C. sahlbergi, Psylopteryx psorosa carpathica, P. p. gutinensis, P. p. retezatica, Chaetopetygopsis maclachlani, Lithax niger, Crunoecia monospina, Athripsodes albifrons, A. cinereus, Ceraclea annulicornis, C. fulva, C. senilis, Ylides kawraiskii, Y. simulans, Oecetis furva, O. tripunctata, Setodes viridis, Leptocerus interruptus, Adicella filicornis, Sericostoma personatum, Beraeodes minutus*. Some of these species are vanished or extinct from these river systems.

The list of caddis fly species from the Someş, Mureş and Crişuri rivers and their tributaries is presented in Table 1. The species are presented with their ecological requirement and the present status of threat in the three river systems.

The caddis flies communities of the upper and lower sectors of these rivers show considerable differences. The mountainous region is rich in species, the number varies from 71 (Someş river system) to 141 (Mureş river system), containing a large number of rare and endemic species. Some of these species are charactheristic to one or two river systems, they do not occur elsewhere, only in the spring sector or they are very rare, ex. *Rhyacophila aquitanica, R. laevis, R. orghidani, Wormaldia pulla, Hydropsyche tabacarui, Plectrocnemia brevis, P. kisbelai, Micrasema minimum, Drusus romanicus, Rhadicoleptus alpestris, Potamophylax jungi, P. pallidum, Chaetopteryx biloba, Oecetis testacea*, etc. Some of these species can be found here in high number. In the lower reaches of these rivers the diversity of the Trichoptera community is considerably reduced, it becomes rather uniform, and only a few species with wide ecological tolerance remain here. In the Mureş river system we can mention only the followings: *Hydropsyche bulgaromanorum, Grammotaulius nigropunctatus, Halesus digitatus, Setodes punctatus*. In the Someş river systems there were collected: *Hydropsyche contubernalis, Cheumatopsyche lepida, Ecnomus tenellus, Limnephilus griseus, Leptocerus tineiformis, Notidobia ciliaris*. The apparently high number of species in the three Crişuri river systems (33) could be lower in the present, because the bulk of information came from oldest publications (MOCSARY, 1900; KERTESZ, 1902; MURGOCI, 1951,1953), and species like *Glossosoma intermedium, Hydropsyche angustipennis, Orthotrichia striata, Brachicentrsu subnubilus, Potamophylax latipennis, Parachiona picicornis, Stenophylax permistus, Silo piceus, Sericostoma flavicorne, S. personatum, Berae pullata, Beraeodes minutus* are absent in the upper sector of these rivers. Our investigations cover only the mountainous sector of these rivers; a more intensive sampling along in the lower sector it is also necessary.

The most diverse caddis fly communities were collected in the Mureş catchment area with 164 trichoptera species, with a high number of species in the mountainous sector (141 species). In the hilly region, with intensive agricultural and industrial activity, the number of species increased to 57. In the lower sector only 5 species were recorded. The aquatic communities were almost distroyed or significantly impoverished.

The situation along the Someş catchment area is similar to those of the Mureş systems, with 113 species, but in the mountainous sector there were identified up to the present only 71 species. The hilly region has still a rich fauna, with 61 species, but the lower sector contains only 7 ecological widespread species.

In the three Crişuri river systems the total number of caddis fly species was 103, most of these species being found in the mountainous region (82). Here the hilly region contains the lowest number of species, only 11, but the lowland courses have a relatively high diversity (30 species) as compared with the two previous river systems.

## Categorization of the threatened species

The most important mention in species categorization must be done here. After the very intensive investigation of the caddis fly fauna of Romania, made mostly by BOTOŞĂNEANU (1952-1975) and MURGOCI (1951-1959), no futhers results have been published for almost 30 years. Only in the nineties some important contibutions were published (CIUBUC, 1993, BOTOŞĂNEANU, 1993, 1995), mostly based on older collected data. The author started to examinate the caddis fly fauna of these river systems in the year 1994. Some of these result have already been published. The intensity of our collecting activities was not uniform along the different rivers, but the quantity of the collected material helps us to draw some conclusions. In this situation, the list of the species presented in each category must be taken carefully. The author's aim was to gather all the information witch can serve in the protective and restoration activities in the river systems investigated. In the present no species are protected by law in Romania. The category used is based on works of KLIMA, 1994, 1998, UHERKOVICH and NÓGRÁDI, 1999.

*0 Unknown (insufficiently known)*. A large number of Trichoptera species from each river systems can be introduce here, due to the very few recent publications in the last 20-30 years. Our collecting data cover only a part (mostly mountainous and hilly sectors) of these river systems, of all these previously records should be reconsidered in the future.

We can mention here a number of 40 species from the Someş river system, 46 from the Mureş river system and 65 from Crişuri river system (see Table 1).

1. *Extinct or vanished.* Here we can mention species whose formerly known habitats have been anihilated or heavily injuried, and authentic specimens have not been collected in the last 40-50 years. A large number of river dwelling trichoptera have no recent data, even if the identification could be valid. The majority of eutrophic pools, for ex., from the suburban area near Cluj, in the Someş river system, have been already destroyed by human activities. This was the only known previously record for *Trichostegia minor* in the area investigated.

We can mention here a number of 11 species from the Someş river system, 16 from the Mureş river system and 11 from the Crişuri river system (see Table 1).

2. *Endangered.* These species have few, isolated populations, generally, with low abundance. Due to the favorable local conditions, the number of specimens in some localities investigated by us may be high. In this category enter the majority of our endemic taxa and some relict or rare species, with diminishing populations all over Europe.

We can mention here a number of 4 species from the Someş river system, 16 from the Mureş river system and 4 from the Crişuri river system (see Table 1).

3. *Vulnerable.* The recent quantity data of these species show diminished populations in comparison with the previous records, or the distribution area of ceratin species are limited because of unfavorable changes in the environment. They have been observed nowadays sporadical in some placeses.

We can mention here a number of 8 species from the Someş river system, 21 from the Mureş river system and 2 from the Crişuri river system (see Table 1).

4. *Presumably vulnerable.* At the present they have strong populations in the river systems investigated, althought these populations may decline and shrink due to degradation of their habitats.

We can mention here a number of 22 species from the Someş river system, 39 from the Mureş river system and 10 from the Crişuri river system (see Table 1).

The rest of the species are not yet threatened. These species are able to adapt themselves to degradation and pollution. Relatively few ceratin species of trichoptera belong to these (more or less discussable) group, and the reactions to the source of pollutions must be investigated for each species in the future for a correct evaluation.

We can mention here a number of 30 species from the Someş river system, 29 from the Mureş river system and 11 from the Crişuri river system (see Table 1). The majority of these species are stream dwelling species in the mountainous area, where the water quality is still good or acceptable. This situation should be changed in the future, if we do not make efforts to keep the recent habitats of these species clear and unpolluted.

**Table 1.**
***River systems***: S – Someş river catchment area, M – Mureş river catchment area, C – Crişul river catchment area, Mo – montainous area, H – hilly region, L – lowland sector
***Ecology***: E, G – all types of running water, K – crenal, R – rithral, P – potamal, L – standing water, M – marches, H – hygropteric biocenosis,
***Source of information***: * only personal collecting data, ° only bibliographical quoted data, published before 1975, . – up to the present have no published data from that river system, + - present, - absent
***The present status of treath***: 0 – unknown or unsufficiently known; 1 – exticnt of vanished; 2 – endangered; 3 – vulnerable; 4 - presumed vulnerable; n - not threatened

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RHYACOPHILIDAE | | | | | | | | | | | | | |
| 1 | *Rhyacophila aquitanica* McLACHL.,1879 | **R** | **3** | + | - | - | **3** | + | - | - | **.** | . | . | . |
| 2 | *Rhyacophila fasciata* HAGEN, 1859 | **R,P** | **n** | + | - | - | **n** | + | - | - | **n** | + | - | - |
| 3 | *Rhyacophila furcifera* KLAPALEK, 1904° | **R** | **.** | . | . | . | **3** | + | - | - | **.** | . | . | . |
| 4 | *Rhyacophila laevis* PICTET, 1834 | **K** | **0** | + | - | - | **4** | + | - | - | **0** | + | - | - |
| 5 | *Rhyacophila mocsaryi* KLAPALEK, 1898 | **R** | **4** | + | - | - | **4** | + | - | - | **0** | + | - | - |
| 6 | *Rhyacophila motasi* BOTOSANEANU, 1957 | **K,R** | **2** | + | - | - | **0** | + | - | - | **0** | + | - | - |
| 7 | *Rhyacophila nubila* (ZETTERSTEDT, 1840) | **R,P** | **n** | + | + | - | **n** | + | + | - | **n** | + | + | - |
| 8 | *Rhyacophila obliterata* McLACHLAN, 1863 | **R** | **n** | + | + | - | **n** | + | + | - | **n** | + | + | - |
| 9 | *Rhyacophila orghidani* BOTOSANEANU, 1952 | **R** | **3** | + | - | - | **3** | + | - | - | **0** | + | - | - |
| 10 | *Rhyacophila philopotamoides* McLACHLAN, 1879° | **K,R** | **0** | + | - | - | **.** | . | . | . | **0** | + | - | - |
| 11 | ***Rhyacophila polonica* McLACHLAN, 1879** | **R** | **4** | + | - | - | **4** | + | - | - | **0** | + | - | - |
| 12 | *Rhyacophila torrentium* PICTET, 1834 | **R** | **0** | + | - | - | **4** | + | - | - | **0** | + | - | - |
| 13 | *Rhyacophila tristis* PICTET, 1834 | **R** | **0** | + | - | - | **4** | + | - | - | **0** | + | - | - |
| | ***Glossosomatidae*** | | | | | | | | | | | | | |
| 14 | *Glossosoma boltoni* CURTIS, 1834 | **R,P** | **.** | . | . | . | **4** | + | + | - | **0** | + | - | - |
| 15 | *Glossosoma conformis* NEBOISS, 1963 | **R** | **0** | + | - | - | **3** | + | - | - | **0** | + | - | - |
| 16 | *Glossosoma discophorum* KLAPALEK, 1902 | **R** | **.** | . | . | . | **0** | + | - | - | **0** | + | - | - |
| 17 | *Glossosoma intermedium* KLAPALEK, 1892 | **R** | **.** | . | . | . | **2** | + | - | - | **1** | - | - | + |
| 18 | *Synagapetus armatus* (McLACHLAN, 1879) ° | **K** | **0** | + | - | - | **.** | . | . | . | **.** | . | . | . |
| 19 | *Synagapetus iridipennis* (McLACHLAN, 1879) ° | **K,R** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 20 | *Synagapetus mosely* (ULMER, 1938) | **K,R** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 21 | *Agapetus delicatulus* McLACHLAN, 1884 | **R,P** | **.** | . | . | . | **4** | + | + | - | **.** | . | . | . |
| 22 | *Agapetus fuscipes* CURTIS, 1834° | **K,R** | **.** | . | . | . | **0** | + | - | - | **.** | . | . | . |
| 23 | *Agapetus laniger* (PICTET, 1834) | **R,P** | **0** | - | + | - | **n** | + | + | - | **0** | + | - | - |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | *Agapetus ochripes* CURTIS, 1834 | **R,P** | . | . | . | . | **n** | + | - | - | . | . | . | . |
| 25 | *Agapetus rectigonopoda* BOTOSANEANU, 1957° | **R,K** | . | . | . | . | . | . | . | . | **2** | + | - | - |
| | ***Hydroptilidae*** | | | | | | | | | | | | | |
| 26 | *Stactobia maclachlani* KIMMIS, 1949° | **H** | . | . | . | . | . | . | . | . | **0** | + | - | - |
| 27 | *Orthotrichia angustella* McLACHLAN, 1865° | **R,P,L** | . | . | . | . | **0** | - | + | - | **0** | - | - | + |
| 28 | *Oxyethira flavicornis* (PICTET, 1834) | **P,L** | **n** | - | + | - | . | . | . | . | **0** | - | - | + |
| 29 | *Itytrichia lamellaris* EATON, 1873 | **R,P** | . | . | . | . | **0** | - | + | - | . | . | . | . |
| 30 | *Hydroptila frocipata* (EATON, 1873) | **R,P** | **n** | - | + | - | **n** | + | + | - | **n** | + | - | - |
| 31 | *Hydroptila lotensis* MOSELY, 1930 | **P,R** | **0** | - | + | - | **3** | + | + | - | **0** | + | - | - |
| 32 | *Hydroptila simulans* MOSELY, 1920 | **R,P** | . | . | . | . | **0** | + | - | - | . | . | . | . |
| 33 | *Hydroptila sparsa* CURTIS, 1834° | **P** | . | . | . | . | **0** | - | + | - | . | . | . | . |
| 34 | *Agraylea sexmaculata* CURTIS, 1834 | **L** | **n** | - | + | - | . | . | . | . | **0** | - | - | + |
| 35 | *Allotrichia pallicornis* (EATON, 1873)* | **R,P** | . | . | . | . | **3** | + | - | - | . | . | . | . |
| | ***Philopotamidae*** | | | | | | | | | | | | | |
| 36 | *Philopotamus montanus* DONOVAN, 1813 | **R** | **0** | + | - | - | **n** | + | - | - | **n** | + | - | - |
| 37 | *Philopotamus variegatus* (SCOPOLI, 1763) | **R** | **n** | + | - | - | **0** | + | - | - | **0** | + | - | - |
| 38 | *Wormaldia occipitalis* (PICTET, 1834) | **H,R** | **0** | + | - | - | **4** | + | + | - | **0** | + | - | - |
| 39 | *Wormaldia pulla* (McLACHLAN, 1878) | **K,R** | **0** | + | - | - | **2** | + | - | - | . | . | . | . |
| 40 | *Wormaldia subnigra* (McLACHLAN, 1865) ° | **R,P** | . | . | . | . | **0** | + | - | - | . | . | . | . |
| | ***Hydropsychidae*** | | | | | | | | | | | | | |
| 41 | *Hydropsyche angustipennis* (CURTIS, 1834) | **R,P** | **n** | - | + | - | **n** | + | + | - | **1** | - | - | + |
| 42 | *Hydropsyche botosaneanui* MARINKOVIC, 1966° | **R** | **0** | + | - | - | . | . | . | . | . | . | . | . |
| 43 | *Hydropsyche bulbifera* McLACHLAN, 1878 | **R,P** | **n** | - | + | - | **n** | + | + | - | **0** | + | - | - |
| 44 | *Hydropsyche bulgaromanorum* MALICKY, 1977° | **P** | . | . | . | . | **0** | - | - | + | **0** | - | - | + |
| 45 | *Hydropsyche contubernalis* McLACHLAN, 1865 | **R,P** | **n** | - | + | + | **n** | + | + | - | **n** | + | + | + |
| 46 | *Hydropsyche fulvipes* CURTIS, 1834 | **R** | . | . | . | . | **0** | + | - | - | **0** | + | - | - |
| 47 | *Hydropsyche instabilis* (CURTIS, 1834) | **R** | . | . | . | . | **n** | + | + | - | **n** | + | - | - |
| 48 | *Hydropsyche modesta* NAVAS, 1925 | **R,P** | **n** | - | + | - | **n** | - | + | - | **n** | + | - | - |
| 49 | *Hydropsyche ornatula* McLACHLAN, 1878° | **P,R** | . | . | . | . | **0** | - | + | - | . | . | . | . |
| 50 | *Hydropsyche pellucidula* (CURTIS, 1834) | **R,P** | **n** | + | + | - | **n** | + | + | - | **n** | + | + | - |
| 51 | *Hydropsyche saxonica* McLACHLAN, 1884 | **R,P** | **4** | - | + | - | **4** | + | + | - | **0** | + | - | - |
| 52 | *Hydropsyche tabacarui* BOTOSANEANU, 1960° | **R** | . | . | . | . | **2** | + | - | - | **2** | + | - | - |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | *Cheumatopsyche lepida* (PICTET, 1834) | **R,P** | **n** | - | + | + | **4** | + | + | - | **4** | + | + | - |
| | ***Polycentropodidae*** | | | | | | | | | | | | | |
| 54 | *Neureclipsis bimaculata* (LINNE, 1758) | **P,R** | **4** | - | + | - | **4** | - | + | - | **.** | . | . | . |
| 55 | *Plectrocnemia brevis* McLACHLAN, 1871 | **K,R** | **.** | . | . | . | **3** | + | - | - | **.** | . | . | . |
| 56 | *Plectrocnemia conspersa* (CURTIS, 1834) | **K,R** | **.** | . | . | . | **4** | + | - | - | **4** | + | - | - |
| 57 | *Plectrocnemia kisbelai* BOTOSANEANU, 1976 | **R** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 58 | *Polycentropus excisus* KLAPALEK, 1894° | **R** | **.** | . | . | . | **0** | + | - | - | **.** | . | . | . |
| 59 | *Polycentropus flavomaculatus* (PICTET, 1834) | **G** | **0** | - | + | - | **4** | + | - | - | **0** | + | - | - |
| 60 | *Polycentropus irroratus* CURTIS, 1835 | **R** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 61 | *Holocentropus picicornis* (STEPHENS, 1836) ° | **L,M** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 62 | *Cyrnus trimaculatus* (CURTIS, 1834) | **L,P,R** | **.** | . | . | . | **4** | + | - | - | **0** | + | - | - |
| | ***Psychomyiidae*** | | | | | | | | | | | | | |
| 63 | *Psychomyia pusilla* (FABRICIUS, 1781) | **P,R,L** | **n** | + | + | - | **n** | + | + | - | **n** | + | - | + |
| 64 | *Lype phaeopa* (STEPHENS, 1836) ° | **L,P,R** | **.** | . | . | . | **0** | - | + | - | **.** | . | . | . |
| 65 | *Lype reducta* (HAGEN, 1868) | **R,P** | **0** | + | - | - | **3** | + | + | - | **.** | . | . | . |
| 66 | *Tinodes kimminsi* SYKORA, 1962* | **K** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| 67 | *Tinodes rostocki* McLACHLAN, 1878° | **R,K** | **4** | + | - | - | **.** | . | . | . | **4** | + | - | - |
| | ***Ecnomidae*** | | | | | | | | | | | | | |
| 68 | *Ecnomus tenellus* (RAMBUR, 1842) | **L** | **n** | - | + | + | **n** | - | + | - | **.** | . | . | . |
| | ***Phryganeidae*** | | | | | | | | | | | | | |
| 69 | *Trichostegia minor* (CURTIS, 1834) ° | **L,P** | **1** | - | + | - | **.** | . | . | . | **.** | . | . | . |
| 70 | *Agrypnia pagetana* CURTIS, 1835 | **L** | **4** | - | + | - | **.** | . | . | . | **.** | . | . | . |
| 71 | *Agrypnia varia* (FABRICIUS, 1793) | **L,M** | **n** | - | + | - | **n** | + | + | - | **.** | . | . | . |
| 72 | *Phryganea bipunctata* RETZIUS, 1783° | **L** | **1** | - | + | - | **.** | . | . | . | **.** | . | . | . |
| 73 | *Phryganea grandis* LINNE, 1758° | **L** | **1** | - | + | + | **0** | - | + | - | **.** | . | . | . |
| 74 | *Oligotricha striata* (LINNE, 1758) ° | **L** | **0** | + | + | - | **0** | + | - | - | **1** | + | - | + |
| 75 | *Oligostomis reticulata* (LINNE, 1761) ° | **G** | **.** | . | . | . | **1** | - | + | - | **.** | . | . | . |
| | ***Brachycentridae*** | | | | | | | | | | | | | |
| 76 | *Brachicentrus montanus* KLAPALEK, 1892° | **R** | **.** | . | . | . | **1** | + | - | - | **0** | + | - | - |
| 77 | *Brachicentrus subnubilus* CURTIS, 1834 | **P** | **.** | . | . | . | **4** | + | - | - | **0** | - | - | + |
| 78 | *Oligoplectrum maculatum* (FOURCROY, 1785) ° | **P,R** | **0** | - | + | - | **0** | + | + | - | **.** | . | . | . |
| 79 | *Micrasema minimum* McLACHLAN, 1876 | **R** | **.** | | . | . | **3** | + | - | - | **0** | + | - | - |
| | ***Limnephilidae*** | | | | | | | | | | | | | |
| 80 | *Ironoquia dubia* (STEPHENS, 1837) | **R** | **.** | . | . | . | **3** | + | + | - | **.** | . | . | . |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | *Apatania carpathica* (SCHMID, 1954) ° | K,R | 0 | + | - | - | . | . | . | . | . | . | . | . |
| 82 | *Drusus biguttatus* (PICTET, 1834) ° | R,K | . | . | . | . | 0 | + | - | - | . | . | . | . |
| 83 | *Drusus brunneus* KLAPALEK, 1898 | R,K | 0 | + | - | - | 4 | + | - | - | . | . | . | . |
| 84 | *Drusus buscathensis* BOTOSANEANU, 1960° | K,R | . | . | . | . | 2 | + | - | - | . | . | . | . |
| 85 | *Drusus discolor* (RAMBUR, 1842) | R | 0 | + | - | - | 0 | + | - | - | . | . | . | . |
| 86 | *Drusus romanicus* MURGOCI & BOTOS.,1954 | R | . | . | . | . | 2 | + | - | - | 0 | + | - | - |
| 87 | *Drusus tenellus* (KLAPALEK, 1898) | R | 0 | + | - | - | 0 | + | - | - | 0 | + | - | - |
| 88 | *Drusus trifidus* McLACHLAN, 1868° | K,R | . | . | . | . | 0 | + | - | - | . | . | . | . |
| 89 | *Ecclysopteryx dalecarlica* KOLENATI, 1848 | R | n | + | - | - | n | + | - | - | n | + | - | - |
| 90 | *Ecclysopteryx madida* (McLACHLAN, 1867) | R | 0 | + | - | - | 4 | + | - | - | 0 | + | + | - |
| 91 | *Limnephilus affinis* CURTIS, 1834 | G | n | + | + | - | n | + | + | - | 0 | - | - | + |
| 92 | *Limnephilus auricula* CURTIS, 1834 | L | n | + | + | - | n | + | - | - | 0 | + | - | + |
| 93 | *Limnephilus binotatus* CURTIS, 1834° | L | 1 | - | - | + | . | . | . | . | . | . | . | . |
| 94 | *Limnephilus bipunctatus* CURTIS, 1834 | L,R | 4 | + | + | - | 4 | + | + | - | 1 | + | + | + |
| 95 | *Limnephilus coenosus* CURTIS, 1834 | R,M | . | . | . | . | 3 | + | + | - | . | . | . | . |
| 96 | *Limnephilus decipiens* (KOLENATI, 1848) | L,R | 4 | - | + | - | n | + | - | - | 4 | + | - | - |
| 97 | *Limnephilus extricatus* McLACHLAN, 1865 | G | n | + | + | - | n | + | + | - | 4 | + | - | - |
| 98 | *Limnephilus flavicornis* (FABRICIUS, 1789) | L | 4 | + | + | - | 0 | - | + | - | 4 | - | + | + |
| 99 | *Limnephilus flavospinosus* (STEIN, 1874) * | L | . | . | . | . | 0 | + | - | - | . | . | . | . |
| 100 | *Limnephilus fuscicornis* RAMBUR, 1842° | L | 1 | - | + | - | 0 | - | + | - | 1 | - | - | + |
| 101 | *Limnephilus griseus* (LINNE, 1759) | G | n | + | + | + | n | + | + | - | 0 | + | - | + |
| 102 | *Limnephilus hirsutus* (PICTET, 1834) | L,P,R | . | . | . | . | 4 | + | + | - | 3 | + | - | - |
| 103 | *Limnephilus ignavus* McLACHLAN, 1865 | L,R | . | . | . | . | 4 | + | - | - | . | . | . | . |
| 104 | *Limnephilus incisus* (CURTIS, 1834) * | L | . | . | . | . | 0 | + | - | - | . | . | . | . |
| 105 | *Limnephilus lunatus* CURTIS, 1834 | L | n | + | + | - | n | + | + | - | 0 | - | - | + |
| 106 | *Limnephilus rhombicus* LINNE, 1758 | G | n | - | + | - | n | + | + | - | 0 | + | - | - |
| 107 | *Limnephilus sparsus* CURTIS, 1834 | G | n | + | + | - | n | + | - | - | . | . | . | . |
| 108 | *Limnephilus stigma* CURTIS, 1834 | G | 4 | - | + | - | 0 | + | - | - | . | . | . | . |
| 109 | *Limnephilus vittatus* (FABRICIUS, 1798) | L,R | n | + | + | - | n | + | + | - | . | . | . | . |
| 110 | *Grammotaulius nigropunctatus* (RETZIUS, 1783) | G | 4 | + | + | - | 4 | + | + | + | 0 | + | + | - |
| 111 | *Grammotaulius nitidus* (MULLER, 1764) ° | L,P | 1 | - | + | + | . | . | . | . | . | . | . | . |
| 112 | *Glyphotaelius pellucidus* (RETZIUS, 1783) ° | G | 0 | - | + | - | 4 | + | - | - | 0 | - | - | + |
| 113 | *Anabolia furcata* BRAUER, 1857* | L,P | . | . | . | . | 4 | + | - | - | . | . | . | . |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 114 | *Asynarchus lapponicus* ZETTERSTEDT, 1848* | R,M | . | . | . | . | 0 | + | - | - | . | . | . | . |
| 115 | *Phacopteryx brevipennis* (CURTIS, 1834) ° | L,M | 0 | - | + | - | 3 | + | - | - | . | . | . | . |
| 116 | *Rhadicoleptus alpestris* (KOLENATI, 1848) | R,M,K | 3 | + | - | - | 3 | + | - | - | 0 | + | - | - |
| 117 | *Potamophylax cingulatus* (STEPHENS, 1837) | R | 3 | + | - | - | 4 | + | - | - | 0 | + | - | - |
| 118 | *Potamophylax jungi* MEY, 1976 | R | . | . | . | . | 2 | + | - | - | 2 | - | + | - |
| 119 | *Potamophylax latipennis* (CURTIS, 1834) | R | 4 | + | - | - | 4 | + | - | - | 0 | + | - | + |
| 120 | *Potamophylax luctuosus* (PILL. & MITT., 1793) | R | 4 | + | - | - | 4 | + | - | - | 4 | + | - | - |
| 121 | *Potamophylax milleni* (KLAPELEK, 1898) ° | R | . | . | . | . | 3 | + | - | - | 1 | + | - | - |
| 122 | *Potamophylax nigricornis* (PICTET, 1834) | R | . | . | . | . | 3 | + | - | - | 0 | + | - | - |
| 123 | *Potamophylax pallidus* (KLAPALEK, 1900) | R | . | . | . | . | 3 | + | - | - | 0 | + | - | - |
| 124 | *Chionophylax mindszentyi* SCHMID, 1951° | K,R | 0 | + | - | - | 0 | + | - | - | 0 | + | - | - |
| 125 | *Halesus digitatus* (SCHRANK, 1781) | R,P,L | 0 | + | - | - | 4 | + | - | + | . | . | . | . |
| 126 | *Halesus tesselatus* (RAMBUR, 1842) | G | 4 | - | + | - | 0 | + | - | - | . | . | . | . |
| 127 | *Melampophylax nepos triangulifera* BOTOS., 1957 | K,R | . | . | . | . | 3 | + | - | - | . | . | . | . |
| 128 | *Melampophylax polonicus gutinicus* BOTOS., 1994° | K,R | 2 | + | - | - | . | . | . | . | . | . | . | . |
| 129 | *Isogamus aequalis* (KLAPALEK, 1907) ° | R | 3 | + | - | - | . | . | . | . | . | . | . | . |
| 130 | *Anisogamus difformis* McLACHLAN, 1875° | R | . | . | . | . | 1 | . | . | . | . | . | . | . |
| 131 | *Parachiona picicornis* (PICTET, 1834) | K | 3 | + | - | - | 3 | + | - | - | 1 | + | - | + |
| 132 | *Micropterna nycterobia* McLACHLAN, 1875 | R,K | n | + | + | - | n | + | + | - | 0 | + | - | - |
| 133 | *Micropterna sequax* McLACHLAN, 1875° | R | 0 | + | - | - | 4 | + | - | - | 0 | + | - | - |
| 134 | *Micropterna testacea* (GMELIN, 1790) | R | 0 | + | - | - | 0 | + | - | - | 0 | + | - | - |
| 135 | *Stenophylax permistus* McLACHLAN, 1895 | R | n | + | + | - | n | + | - | - | 1 | + | - | + |
| 136 | *Stenophylax vibex* (CURTIS, 1834) | R | 4 | + | + | - | 0 | + | - | - | 0 | + | - | - |
| 137 | *Allogamus auricollis* (PICTET, 1834) | R | 4 | + | - | - | 0 | + | - | - | . | . | . | . |
| 138 | *Allogamus dacicus* SCHMID, 1951 | R | . | . | . | . | 2 | + | - | - | . | . | . | . |
| 139 | *Allogamus uncatus* (BRAUER, 1857) | R | 4 | + | - | - | 4 | + | - | - | 0 | + | - | - |
| 140 | *Chaetopteryx biloba* BOTOSANEANU, 1960 | R,K | 2 | + | - | - | . | . | . | . | 0 | + | - | - |
| 141 | *Chaetopteryx bosniaca cissylvanica* BOTOS., 1994 | R | 0 | + | - | - | 0 | + | - | - | 0 | - | + | - |
| 142 | *Chaetopteryx polonica* DZIEDZIELEWICZ, 1889° | R | 3 | + | - | - | . | . | . | . | . | . | . | . |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 143 | *Chaetopteryx sahlbergi* McLACHLAN, 1876° | **R** | . | . | . | . | . | . | . | . | **1** | - | - | + |
| 144 | *Psylopteryx curviclavata* BOTOSANEANU, 1957 | **R,K** | **0** | + | - | - | **2** | + | - | - | **0** | + | - | - |
| 145 | *Psylopteryx psorosa carpathica* SCHMID, 1952° | **K,R** | **0** | + | - | - | . | . | . | . | . | . | . | . |
| 146 | *Psylopteryx psorosa gutinensis* MEY & BOTO., 1985° | **K,R** | **0** | + | - | - | . | . | . | . | . | . | . | . |
| 147 | *Psylopteryx psorosa retezatica* BOTO. & SCHN.,1978° | **K,R** | . | . | . | . | **0** | + | - | - | . | . | . | . |
| 148 | *Chaetopterygopsis maclachlani* STEIN, 1874° | **R,K** | . | . | . | . | . | . | . | . | **2** | + | - | - |
| 149 | *Annitella lateroproducta* (BOTOSANEANUI, 1952) | **R** | **3** | + | - | - | **4** | + | - | - | **4** | + | - | - |
| 150 | *Annitella obscurata* (McLACHLAN, 1876) * | **R,P** | . | . | . | . | **4** | + | - | - | . | . | . | . |
| | ***Goeridae*** | | | | | | | | | | | | | |
| 151 | *Goera pilosa* (FABRICIUS, 1775) | **R,P,L** | **0** | - | + | - | **4** | + | - | - | **4** | + | - | - |
| 152 | *Lithax niger* (HAGEN, 1859) ° | **K,R** | **0** | + | - | - | **0** | + | - | - | . | . | . | . |
| 153 | *Lithax obscurus* (HAGEN, 1859) * | **K,R** | . | . | . | . | **0** | + | - | - | . | . | . | . |
| 154 | *Silo graellsi* PICTET, 1865 | **R** | **n** | + | - | - | **n** | + | - | - | **0** | + | - | - |
| 155 | *Silo pallipes* (FABRICIUS, 1781) | **R** | . | . | . | . | **3** | + | - | - | . | . | . | . |
| 156 | *Silo piceus* BRAUER, 1857 | **R** | **0** | - | + | - | **4** | + | - | - | **1** | + | - | + |
| | ***Lepidostomatidae*** | | | | | | | | | | | | | |
| 157 | Lepidostoma hirtum *(FABRICIUS, 1775)* | **P,R** | . | . | . | . | **4** | + | + | - | **4** | + | - | - |
| 158 | Lasiocephala basalis *(KOLENATI, 1848)* | **R,P** | . | . | . | . | **3** | + | + | + | . | . | . | . |
| 159 | Crunoecia monospina *BOTOSANEANU, 1960°* | **R,K** | . | . | . | . | **2** | + | - | - | . | . | . | . |
| | ***Leptoceridae*** | | | | | | | | | | | | | |
| 160 | Athripsodes albifrons *(LINNE, 1758)* ° | **R** | . | . | . | . | **0** | + | - | - | . | . | . | . |
| 161 | Athripsodes bilineatus *(LINNE, 1758)* | **R,P** | . | . | . | . | **4** | + | + | - | . | . | . | . |
| 162 | Athripsodes cinereus *(CURTIS, 1834)* ° | **L,P** | . | . | . | . | **1** | - | + | - | . | . | . | . |
| 163 | Athripsodes commutatus *(ROSTOCK, 1874)* | **R,P** | . | . | . | . | **3** | + | + | - | . | . | . | . |
| 164 | Ceraclea annulicornis *(STEPHENS, 1836)* ° | **L,P** | **1** | - | + | - | **1** | - | + | - | . | . | . | . |
| 165 | Ceraclea dissimilis *(STEPHENS, 1836)* | **L,P** | . | . | . | . | **0** | - | + | - | **n** | + | - | - |
| 166 | Ceraclea fulva *(RAMBUR, 1842)* ° | **L** | **1** | - | + | - | . | . | . | . | . | . | . | . |
| 167 | Ceraclea senilis *(BURMEISTER, 1839)* ° | **L** | . | . | . | . | **0** | - | + | - | . | . | . | . |
| 168 | Mystacides azurea *(LINNE, 1761)* | **L,P** | **4** | - | + | - | **4** | + | + | - | . | . | . | . |
| 169 | Mystacides longicornis *(LINNE, 1761)* | **L** | **n** | - | + | - | **1** | - | + | - | . | . | . | |
| 170 | Mystacides nigra *(LINNE, 1761)* | **L** | **0** | - | + | - | **4** | + | - | - | . | . | . | . |
| 170 | Ylodes kawrauskii *(MARTYNOV, 1909)* ° | **P,R** | **2** | - | + | - | **2** | + | - | - | . | . | . | . |
| 172 | Ylodes simulans *(TJEDER, 1929)* ° | **P,R** | . | . | . | . | **3** | - | + | - | . | . | . | . |
| 173 | Oecetis furva *(RAMBUR, 1842)* ° | **L** | . | . | . | . | **1** | + | - | - | . | . | . | . |

**Table 1. (continued)**

| | | E | S | Mo | H | L | M | Mo | H | L | C | Mo | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 174 | Oecetis lacustris *(PICTET, 1834)* | **L** | **4** | - | + | - | **.** | . | . | . | **.** | . | . | . |
| 175 | Oecetis notata *(RAMBUR, 1842)* * | **P,L** | **.** | . | . | . | **.** | . | . | . | **0** | + | - | - |
| 176 | Oecetis ochracea *(CURTIS, 1825)* | **L** | **n** | - | + | - | **.** | . | . | . | **0** | - | - | + |
| 177 | Oecetis testacea *(CURTIS, 1834)* * | **L,P** | **.** | . | . | . | **.** | . | . | . | **2** | + | - | - |
| 178 | Oecetis tripunctata *(FABRICIUS, 1793)* ° | **L, P** | **.** | . | . | . | **1** | - | + | - | **.** | . | . | . |
| 179 | Setodes punctatus *(FABRICIUS, 1793)* | **P** | **0** | - | + | - | **0** | + | - | + | **0** | + | - | - |
| 180 | Setodes viridis *(FORUCROY, 1785)* ° | **P** | **1** | - | + | - | **.** | . | . | . | **.** | . | . | . |
| 181 | Leptocerus interruptus *(FABRICIUS, 1775)* ° | **R,P** | **.** | . | . | . | **.** | . | . | . | **1** | - | - | + |
| 182 | Leptoceris tineiformis *CURTIS, 1834* | **L** | **n** | - | + | - | **n** | - | + | - | **.** | . | . | . |
| 183 | Adicella filicornis *(PICTET, 1834)* ° | **K** | **.** | . | . | . | **0** | + | - | - | **0** | + | - | - |
| | ***Sericostomatidae*** | | | | | | | | | | | | | |
| 184 | Notidobia ciliaris *(LINNE, 1761)* | **R,L** | **n** | + | + | - | **0** | + | - | - | **0** | - | - | + |
| 185 | Oecismus monedula *(HAGEN, 1859)* | **R** | **3** | + | - | - | **1** | + | - | - | **3** | + | - | - |
| 186 | Sericostoma flavicorne *SCHNEIDER, 1845* | **R,P** | **.** | . | . | . | **n** | + | - | - | **1** | + | - | + |
| 187 | Sericostoma personatum *(KIRBY & SPENCE, 1826)* ° | **R,K** | **0** | + | - | - | **1** | + | - | - | **1** | - | - | + |
| | ***Bereidae*** | | | | | | | | | | | | | |
| 188 | Beraea pullata *(CURTIS, 1834)* | **G** | **3** | + | + | - | **3** | + | + | - | **1** | - | - | + |
| 189 | Beraeodes minutus *(LINNE, 1761)* ° | **G** | **.** | . | . | . | **0** | + | - | - | **1** | - | - | + |
| 190 | Ernodes articularis *(PICTET, 1834)* | **K,R** | **0** | + | - | - | **3** | + | - | - | **.** | . | . | . |
| 191 | Ernodes vicinus *(McLACHLAN, 1879)* | **K** | **.** | . | . | . | **2** | + | - | - | **.** | . | . | . |
| | ***Odontoceridae*** | | | | | | | | | | | | | |
| 192 | Odontocerum albicorne *(SCOPOLI, 1763)* | **R** | **4** | + | - | - | **4** | + | - | - | **.** | . | . | . |
| 193 | Odontocerum hellenicum *MALICKY, 1972* | **R** | **.** | . | . | . | **3** | + | - | - | **0** | + | - | - |

## Conclusions

The Someş, Mureş and Crişuri river systems have a rich trichoptera fauna. Because of the different geographical and geological conditions, as well as the different sources of pollutions wich act along the river vallyes, the present status of threat of the trichoptera communities in these rivers can differ strongly. The trend of changes is directed towards the impoverishment of the caddis flies, with specific situations in each river sectors. A large number of stream dwelling trichoptera caddis flies in the mountainous area have strong populations, althought these populations may decline due to the degradation of habitats, mostly near localities (villages, towns). The high scientific value of these habitats consists in a large number of endemic or relict species developed in the spring sectors wich are strongly endangered by the wood-cutting actions here. In the mountainous area the construction of the dam-lakes (ex. in valleys of the Someşul Cald and Someşul Rece rivers) modified the water flow in these rivers. In addition, the unregulated tourism and construction of cottages can accelerate the disappearance of some suitable habitats or sensitive species. The large agricultural crops in the immediate vicinity of the river banks, mostly in the middle and lower sections, pollute seriously the water with fertilizers and pesticides. The communal and industrial sewage-production of the industrial establishments along the middle and lower sector of these rivers is so intense that in some sectors it destroys the original fauna, some species have disappeared completely. The lower sector of these rivers became uniform, with a few ecologically indifferent species.

## References


Botoşăneanu, L. (1952): *Rhyacophila furcifera* (KLAPALEK) BOTOS. syn. *Rhy. Mayeri var furcifera* KLAPALEK, 1904. Comun. Acad. R.P.R., 2, 9/10: 547-550.

Botoşăneanu, L. (1952): *Rhyacophila orghidanui* n.sp. (Trichcoptera, Rhyacophilidae) din Munţii Apuseni şi R.P.R., Comun.Acad.R.S.R., 2,11-12: 721-724.

Botoşăneanu, L. (1955): Note trichopterologice I. Bul.ştiinţ. Secţ.Şti.Biol., 7,3: 791-802.

Botoşăneanu, L. (1956): Contributions a la connaisance des stades aquatiques des Trichopteres crenobiontes: *Rhyacophila laevis* Pict., *Wormaldia triangulifera* McLach., *Drusus romanicus* Murg. et Botosaneanu., *Silo varipilosa* Bots. (Trichoptera).-Beitr.Entom. 6:590-624.

Botoşăneanu, L. (1957): Recherches sur les Trichopteres (imagos) de Roumania. Tjdsch. Ent., 100,2: 179-194.

Botoşăneanu, L. (1957): Quelques trichopteres nouveaux de Roumanie. Tjdsch. Ent. 100,2: 598-603.

Botoşăneanu, L. (1957): Neue Trichopteren Arten aus Rumanien. Senckenbergiana biol., 38, ": 61-65.

Botoşăneanu, L. (1958): Sur quelques *Triaenodes* (Trichoptera, Leptoceridae) du groupe *conspersa* CURTIS. Opusc.Ent. 28: 123-128.

Botoşăneanu, L. (1959): Cercetări asupra trichopterelor din Masivul Retezat şi Munţii Banatului. Biblio. Biol.Anim.,Ed.Acad.R.S.R., 1: 1-166.

Botoşăneanu, L. (1959): Recherches sur Trichopteres cavernicoles, principalment sur ceux collections "Biospeologica". Archs. Zool. Exp. et gener. Notes et Revue, 97/1: 32-50.

Botoşăneanu, L. (1960): Revision de quelques especies de *Philopotamus* Leach et de *Wormaldia* McL. (Trichoptera, Philopotamidae).-Acta.Soc.Entom.Cechosl. 57:223-228.

Botoşăneanu, L. (1960): Description de quatre nouvelles especies de Trichopteres de Roumanie. Ann. Mag. Nat. Hist., 13,3: 113-120.

Botoşăneanu, L. (1960): *Drusus buscatensis* n.sp. (Trichoptera, Ecclysopteryginae). Cas.Ces. Spol. Ent., 57:36-370.

Botoşăneanu, L. (1961): Materiaux por servir a'la connaissance des Trichopteres d'Europe orientale et centrale. Folia Ent. Hung., Ser.nov. 14,2: 11-91.

Botoşăneanu, L. (1965): Neue trichopterologische Fange in Poland, Rumanien und Bulgarien. Latv. Ent., 10: 53-60.

Botoşăneanu, L. (1966): Genurile *Stenophylax* şi *Micropterna* STEIN (Trichoptera) în România. Prezentare cu caracter sistematic. Lucr. Inst. Speol. "E. Racoviţă", 5: 99-114.

Botoşăneanu, L. (1967): Sur quelques *Plectrocnemia* des Carpates de Roumanie (Trichoptera, Polycentropodidae), Reichenbachia, 8,23: 269-273.

Botoşăneanu, L. (1972): Pour une milleure connaissance des *Micrasema* d'Europe (Trichoptera, Brachicentridae).-Fragmenta Entomologica 10(2): 65-106.

Botoşăneanu, L. (1973): Les Trichopteres (Insecta, Trichoptera) de l'espace carpato-balcanique, fournisseurs de documntes pour l-evolution. Riv.Idrobiol. (Perugia), 12, 2/3: 119-152.

Botoşăneanu, L. (1975): Die endemischem Trichopteren der Karpaten. Verh. Sechsten Int Symp. uber Entomofaunistk in Mitteleuropa: 91-103.

Botoşăneanu, L. (1993): A new caddisfly species from Romania and several species new to the country's fauna (Trichoptera). Ent. Zeitsch. 103/21:399-404.

Botoşăneanu, L. (1995): Additional documentes to the knowledge of the Trichoptera of Roumania, with data on European taxa from outside this country (Insecta, Trichoptera). Faun. Abh. Mus. Toerk. Drezden 20,6:57-88.

Ciubuc, C. (1993): Checklist of Romanian Trichoptera (Insecta). Extr. des Trav du Mus. d'Hist.Nat. Gr. Antipa, Bucuresti, 23: 11-147.

Higler, L., Tolkamp, H. (1982): Hydropsychidae as bio-indicators.-Environmental Monitoring and Assessment 3: 331-341.

Klima, F. (1994): Die aktuelle Gefahrdungsituation der Kocherfliegen Deutchlands (Insecta,Trichoptera).-Natur und Landschaft 69(11):511-518.

Klima, F. (1998): Rote Liste der Kocherfliegen (Trichoptera). In: Binot A et colab.: Rote Liste gefarderter Tiere Deutschlands.-Schriftenreiche fur Landschaftspflege und Naturschutz 55: 112-118.

Murgoci, A. (1951): Contribuţii la cunoaşterea trichopterelor din peşterile Munţilor Apuseni şi din regiunile Huniedoara şi Severin. Bull. Secţ. Şti.Biol, 3,4: 751-764.

Murgoci, A. (1953): Câteva genuri şi speci noi de trichoptere pentru fauna Romămiei. Bull. Secţ. Şti.Biol, 5,1: 29-36.

Murgoci, A. (1959): Donnes sur les imagos et les larves des Leptocerides (Trichoptera) de la R.P.R. Lucr. Ser. Şti. Staţiunii Zool. Mar. Agigea: 445-452.

Uherkovich Á., Nógrádi S. (1999): Protecetd and threatened caddisflies (Trichoptera) of Hungary. Proc. of the 9th Int. Symp. on Trichoptera, Chiang Mai: 291-297.

Ujvári J. (1972): Geografia apelor României. Edit. Ştiinţ., Bucureşti.

Ujvárosi L. (1995):Two new and some rare trichoptera species in the Romanian fauna. Bul. inf. Soc.lepid.rom., 6(1-2): 151-155.

Ujvárosi L. (1997): Study on the Trichoptera fauna in the Romanian section of the River Crişul Alb catchment area. Tiscia monograph series. Szolnok-Szeged-Tg.Mureş, pp.295-299.

Ujvárosi L. (1998): Trichopterele (Insecta: Trichoptera) din zona Cheile Someşului Cald (Ic Ponor). Bul.inf.Soc.lepid.rom., 9(3-4): 265-268.

Ujvárosi L. (1998): Four Trichoptera species new in the Romanian fauna. Entomol. Rom. 3:73-78.

Ujvárosi L., Nógrádi S. (1999): The female of *Potamophylax jungi* Mey, 1976 (Trichoptera, Limnephilidae). Braueria (Lunz am See, Austria) 26:24.

LUJZA UJVAROSI
"Babeş-Bolyai" University, Faculty of Biology and Geography,
Dept. of Zoology,
5-7 Clinicilor St.,
RO 3400 Cluj-Napoca
luiza@biolog.ubbcluj.ro

# SPECIES AND SUBSPECIES OF FISH AND LAMPREYS ENDEMIC OR ALMOST ENDEMIC TO THE DRAINAGE AREA OF THE TISA RIVER

*Petru M. Bănărescu*

**Abstract**

Endemic to a small thermal pond in the Tisa basin is *Scardinius racovitzai*, probably a recent offshoot of *S. erythrophtalmus*; almost endemic is the predatory resident lamprey *Eudontomyzon danfordi*, of a genus displaying a disjunct European-Eastern Asian range. The subspecies *Sabanejewia balcanica radnensis* is endemic to the upper sector of the tributary river Mureş; the populations of the middle and lower reach of this river, which are morphologically closer to the subspecies *balcanica* are genetically closer to *radnensis*.

**Keywords:** fish, lampreys, endemics, Tisa River basin

The Tisa river is the largest tributary of the Danube. Two species of lampreys and eight of bony fish, or ten, if we consider the Macedonian subspecies *Gobio uranoscopus elimeius* and *Zingel streber balcanicus* as specifically distinct from their Danubian relatives, are endemic to the catchment area of the Danube, but only three of these twelve species are widely distributed throughout the entire Danube basin, including the Tisa River and its tributaries: *Gobio uranoscopus, Gymnocephalus schraetser* and *Zingel streber*. The lamprey *Eudontomyzon vladykovi* and the fish species *Rutilus pigus* and *Sabanejewia romanica* are present in a small area of the Tisa drainage, but the largest part of their range includes sectors of the Danube outside the Tisa River system. Four other Danube basin endemics do not live in the Tisa River system. Finally, one fish, *Scardinius racovitzai* is endemic, and the lamprey *Eudontomyzon danfordi* is almost endemic to the Tisa system, while the subspecies *Sabanejewia balcanica radnensis* is endemic to the system of the river Mureş, the largest tributary of the Tisa.

The rudd *Scardinius racovitzai* has been described by Müller (1958) from a small thermal pond at Băile Episcopeşti (formerly Püspök-Fürdő, Bischofsbad) on the rivulet Peţea, tributary of the Crişul Repede River, Tisa drainage area. Bănărescu (1964) considered it only a subspecies of the widely ranging, Central European *S. erythrophtalmus*. New studies demonstrated that there are not only slight morphological and stronger physiological differences between the two species, but also behavioral ones (Crăciun, unpublished PhD dissertation). *S. racovitzai* deserves therefore a specific rank (see also Kottelat, 1997).

Müller (1958) considers, in the original description of the *S. racovitzai*, that this species may have an old, possibly a Miocen origin, deriving from the fauna which inhabited Europe when the continent enjoyed a subtropical climate. I personally believe that this species is a recent derivative of the Central European common rudd, *S. erythrophtalmus*. A thorough comparison, using also molecular techniques, of both species and of the three other members of the genus (an Italian and two Greek species - Kottelat, 1997) is necessary for clarifying the problem.

*Eudontomyzon danfordi* is a predatory species of lampreys present in the upper stretches of the Tisa and of all its tributaries which have a montane sector, except the southernmost one, the Bega in the Banat (fig. 1 - note that the species inhabits all tributaries of the Tisa in Slovakia, but is absent from all direct tributaries of the Middle Danube). Outside the drainage area of the Tisa, *E. danfordi* is present also in one or two rivers in the Banat: the Timiş (with its subtributaries) and, according to information which need verification, the Cerna (fig. 1).

It is worth mentioning that *E. danfordi* is, besides *E. morii* and the three species of *Ichthyomyzon*, one of the few predator lampreys sedentary in rivers; most of the other predatory lampreys are migratory (anadromous) and all other sedentary species are non predatory (contributors in Lee et al., eds, 1980; Hardisty in Holcik, ed., 1986).

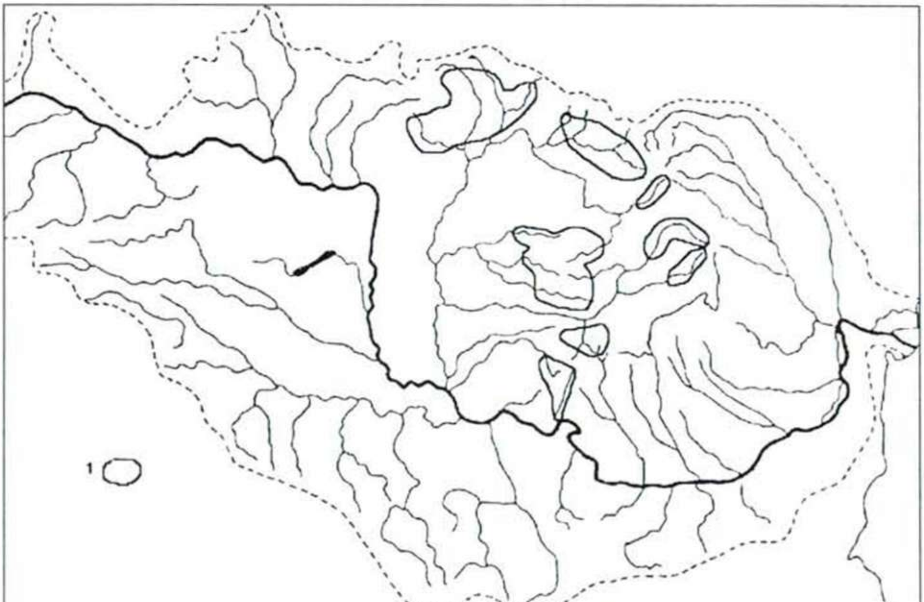



**Fig. 1. Distribution of the predatory lamprey *Eudontomyzon danfordi***

The genus *Eudontomyzon* comprises four other species:

1. the non-predatory *E. vladykovi* in the drainage area of the upper and middle Danube (sympatric with *E. danfordi* in Timiş River and its tributaries) (Bănărescu, 1969);

2. the non-predatory *E. mariae* in the drainage area of the lower Danube, in the more eastern rivers on the northern watershed of the Black Sea (Dnjestr or Nistru, Dnjepr or Nipru etc.), in the river Vistula (Baltic Sea watershed), possibly also in the Vardar (Aegean Sea watershed) and the Drin River (Adriatic Sea Watershed);

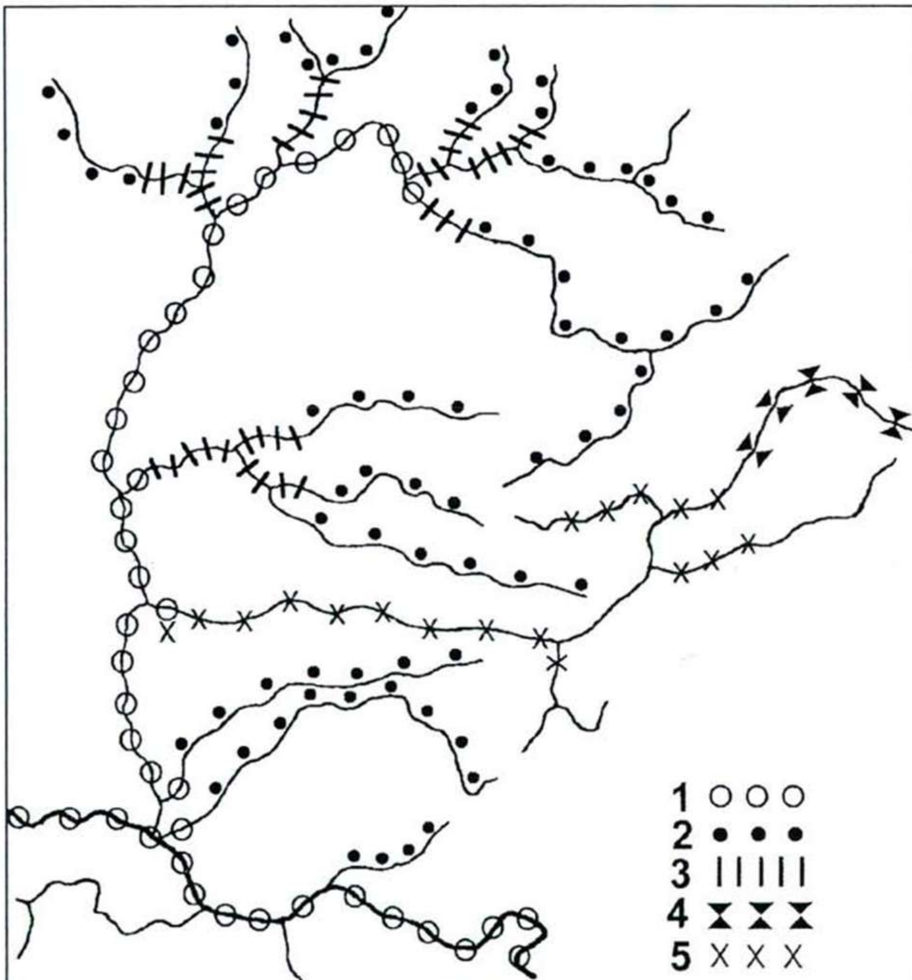



**Fig. 2. Distribution of the subspecies of *Sabanejewia Balcanica* in the drainage area of the Tisa River and in the rivers from the Banat. 1 - *S. balcanica bulgarica*; 2 - *S. balcanica balcanica*; 3 - intergrades between the subspecies *balcanica* and *bulgarica*; 4 - *S. balcanica radnensis*; 5 - populations morphologically closer to *S. balcanica balcanica* but genetically closer to *S. balcanica radnensis*.**

3. the non-predatory *E. hellenicus* in the rivers Strymon or Struma (Aegean Sea watershed) and Louros (Ionnian Sea watershed) (Renaud, in Holcik, 1986);

4. the little-known, probablly predatory *E. morii* in the river Yalu, Korea (Holcik, in Holcik, 1986).

The zoogeographic position of *E. danfordi*, and of the genus *Eudontomyzon* cannot be established until the relations between the Eastern Asian *E. morii* and the four European species are clarified.

The subspecies *Sabanejewia balcanica radnensis* is endemic to the upper sector of the river Mureş, between the headwaters and the town Reghin. The populations from the middle and lower Mureş, downstream Reghin and the tributaries are morphologically more similar to the subspecies *S. balcanica balcanica*, which lives in the other tributaries of the Tisa, Tur, Someş, Criş and in the rivers from the Banat (Bega, Timiş) than to *radnensis* and are therefore reported in the literature as *balcanica* (Bănărescu, 1964; Bănărescu et al., 1973).

There is, however, an important difference between the presumed *balcanica* from the middle and lower sectors of the Mureş and the true *balcanica* from the rivers Someş, Timiş etc. In the lower sectors of the latter rivers a gradual and continuoaus intergradation takes place between the "typical" *balcanica* from the upper and middle sectors and the subspecies *S. balcanica bulgarica*, which lives in the Danube and Tisa, the specimens from the lowermost stretches of these rivers being almost typical *bulgarica* (fig 2).

No such intergradation takes place in the lower sector of the river Mureş. The populations remain morphologically unchanged from the middle sector to the confluence of the river with the Tisa. At the confluence they meet on a length of about 70 km with specimens of *bulgarica*, living sympatrically with these, without any intergradation or hybridization, like "good" species. This proves that the presumed balcanica inhabiting the other tributaries of the Tisa is genetically closer to *S. balcanica radnensis*. The complex "true *radnensis*" and "middle-lower Mureş *balcanica*-like form" build a monophyletic taxon, endemic to the entire Mureş River system, i.e. to a part of the Tisa River drainage area.

## References

BĂNĂRESCU, P., 1964 - Pisces. Osteichthyes. *Fauna R. P. Române*, **13**, Edit. Acad., Bucureşti, 1-962;

BĂNĂRESCU, P., 1969 - Ciclostomata şi Chondichthyes. *Fauna R. S. România*, **12** (1), Edit. Acad., Bucureşti, 1-103;

BĂNĂRESCU, P., NALBANT, T., CHELMU, SILVIA, 1972 - Revision and geographical variation of *Sabanejewia aurata* in Romania and the origin of *S. bulgarica* and *S. romanica* (Pisces). *Annot. zool. botan.*, Bratislava, **75**, 1-49;

HOLCIK, J. (ed.), 1986 - The Freshwater Fishes of Europe. Aula Verl., Wiesbaden, **1**, 1-314;

KOTTELAT, M., 1997 - European Freshwater Fishes. *Biologia*, Bratislava, **52**, suppl. 5, 1-271;

LEE, D.S., GILBERT, C.R., COHUTT, C.H., JENKINS, R.E., McALLISTER, D.E., STAUFFER Jr, J.R. (eds.), 1980 - Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History, 1-870;

MULLER, G., 1958 - *Scardinius racovitzai* n. sp. (Pisces, Cyprinidae), eine reliktare rotfeder aus Westrumanien. *Senck. biol.*, **30**, 165-168.

P. M. BĂNĂRESCU
Research Institute of Biology
Department of Biosistematics
Splaiul Independenţei 296
79651 Bucureşti
România

# FISH SPECIES WITH RESTRICTED RANGES IN THE TISA RIVER DRAINAGE AREA

*Petru M. Bănărescu*

## Abstract

Among the native fish species from the Tisa River drainage area some are restricted to a certain part, or have a disjunct range. The most obvious patterns and histories of such distributions are discussed in the present paper.

**Keywords:** zoogeography, ranges, phyletic relations.

## Discussion

The Tisa river is the largest tributary of the Danube. Two species of lampreys, five of sturgeons - three of which are migratory / and 53 of bony fish - gobies of brackish water with Ponto-Caspian origin, even if fully adapted to freshwater, being not included in this figure, are native to the drainage area of this river.

None of these species occurs throughout the entire drainage area of the Tisa. Montane species - *Salmo trutta, Thymallus thymmalus, Cottus gobio* etc. are present only in the upper sectors of the Tisa and its tributaries; many others - *Abramis ballerus, A. sapa, Gymnocephalus schraetser, G. baloni* etc. are confined to the Tisa River and to the lower sectors of its tributaries. The restricted distribution of these species has ecological bases, being not significant in genetical or historical biogeography.

Significant are the species restricted to a part of the Tisa basin, although they have adequate life conditions also in other parts.

Two species, the eastern sculpin, *Cottus poecilopus*, and a dace, *Telestes souffia*, occur only in the upper Tisa and the upper stretches of its tributaries, northern (Ukrainian) and southern (Romanian) as well. Their ranges in the Tisa basin are the same, but their general ranges, i.e. their biogeographical positions are quite different. *C. poecilopus* is a northern, cold-adapted species, ranging from the Scandinavian Peninsula and north-eastern European Russia to the northern and eastern Carpathians in the drainage areas of the Danube, Nistru and Vistula. Its range in the Danube basin encompasses the upper sectors of the tributaries of the middle Danube in Slovakia, the upper Tisa River and its tributaries and the northern tributaries of the rivers Siret and Prut (Fig. 1) (Antipa, 1909; Vladykov, 1931; Bănărescu, 1964; Harka, 1997; Holcsik, personal information), the populations from the southern tributaries of the Tisa and from the tributaries of the Siret being the southernmost ones. This species obviously has a northern origin and probably entered the Carpathian rivers during the Ice Age.

Contrary to *C. poecilopus*, *Telestes souffia* has a rather southern distribution; it inhabits the drainage area of the Rhone and of other rivers in southern France, that of the upper Rhine, the river Soca or Isonzo in the Istria Peninsula, possibly also other rivers on the western Balkan watershed, as well as the south-western tributaries of the Danube, from Germany to Croatia and Bosnia; a distinct subspecies or closely related species: *T. muticellus* lives in northern and central Italy (Berg, 1932; Vladykov, 1931; Bianco, 1979; Leiner and Popovic, 1981; Allardi and Keith, eds., 1991). The range of the species is hence widely disjunct, the population from the upper Tisa being quite distant from the main range of the species (fig. 2). These populations are also the northern-most ones, contrary to those of *Cottus poecilopus*, which are the southern-most ones of their species.

It is worth mentioning that the two other species of the genus have southern ranges, too: *T. polylepis* is confined to a few small tributaries of the river Sava, the south-western area of the Danube drainage and *T. turskyi* is endemic to the river Cikola on the western Balkan watershed (Bănărescu and Herzig-Straschill, 1998).

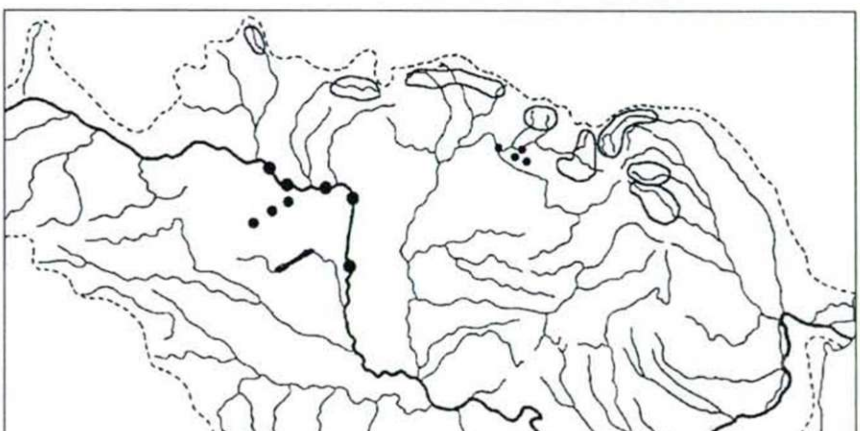



**Fig. 1. Distribution of *Cottus poecilopus* (1) and *Rutilus pigus* (2) in the basin of the middle and lower Danube**

The disjunct distribution of any species or monophyletic superspecific taxon - excepting some species with strong dispersal abilities derives from a wider and continuous range followed by extinction in a part of this range. It is therefore obvious that *T. souffia* had once a wide and continuous range throughout the drainage area of the middle Danube, or even throughout the entire basin of the Danube later, perhaps during the Ice Age, becoming extinct from the area between the upper Tisa and the River Sava, a south-western tributary of the Danube.

Restricted to a small area of the Tisa drainage is also the loach *Sabanejewia romanica*, present only in six of the seven south-western tributaries of the Mureş River: Sebeş, Cugir, Beriu, Strei, Cerna Hunedoreană and Dobra (Bănărescu, 1953, 1964 and recent field investigations; fig. 3). The species is absent from the seventh south-western tributary of the Mureş, the river Pian that flows between Sebeş and Cugir, as well as from the south-eastern and northern ones. Besides the tributaries of the lower Danube: Topolniţa, Jiu, Olt (both in Transylvania and south of the Carpathians), Vedea and their subtributaries, being absent in the more eastern ones (fig. 4).

Hence, the range of this species is disjunct, too, since there is no direct contact between the southern tributaries of the Mureş and those of the lower Danube.

For explaining this disjunction, and the zoogeographic position of *S. romanica*, it is necessary to determine its phyletic affinities. Two alternative options have been proposed in this problem:

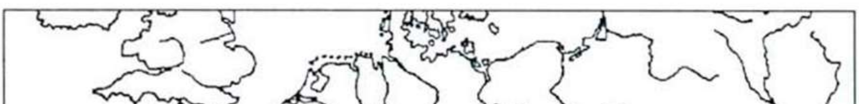



**Fig. 2. Range of *Telestes souffia* (1) and its closest relaive, *T. muticellus* (2), according to the data of Vladykov, 1931, Berg, 1932 and Bianco, 1979**

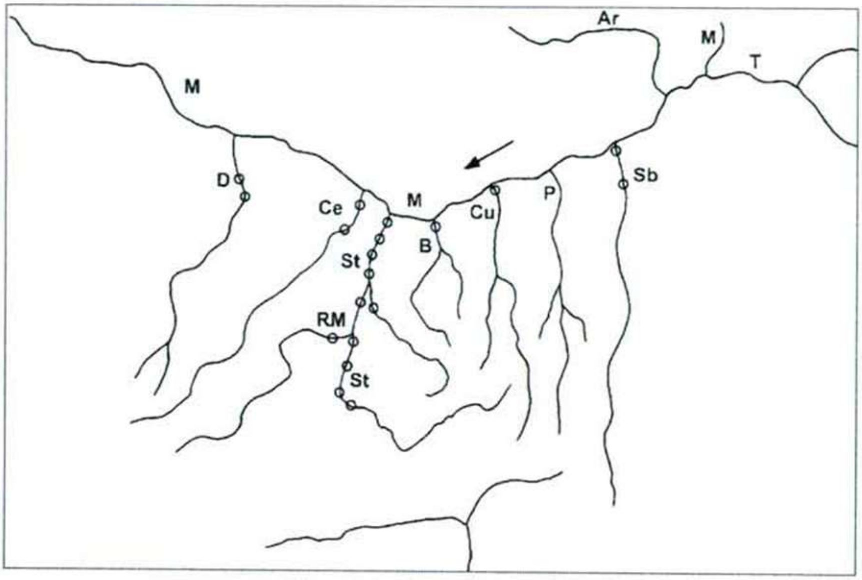



Fig. 3. Distribution of *Sabanejewia romanica* in the tributarie of the Mureş River. M - Mureş; T - Târnava; Ar - Arieş; Sb - Sebeş; Pian; Cu - Cugir; B - Beriu; St - Strei; RM - Râul Mare; Ce - Cerna Hunedoreana; D - Dobra (according to own field inverstigations)

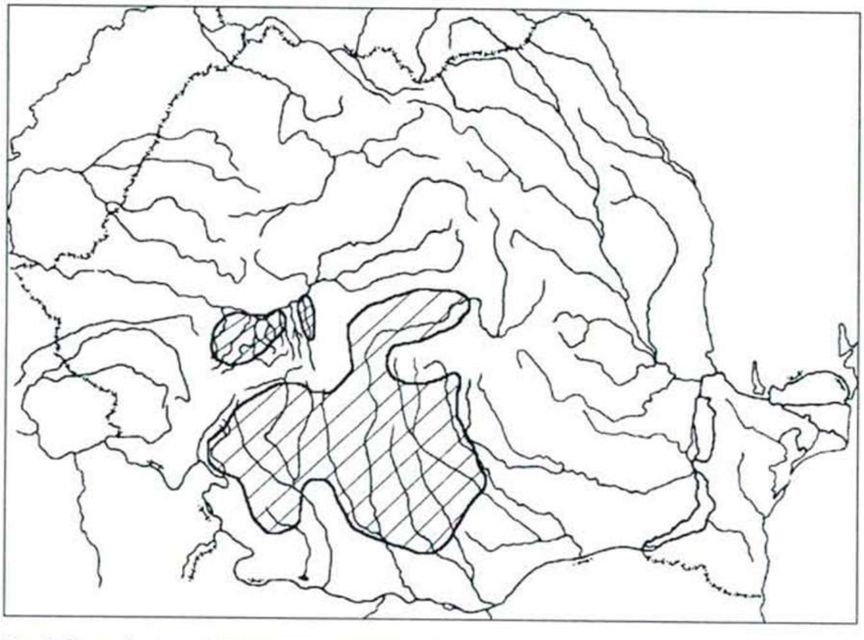


Fig. 4. General range of *Sabanejewia romanica* (according to own field investigations)

1. This species is morphologically very similar to the widely distributed *S. aurata,* a species subject to a strong geographical variability, especially in the Danube basin. The *S. aurata* subspecies is more similar to *S. romanica* is *S. aurata vallachica* from the southern and south-eastern tributaries of the Danube in Romania, the populations most similar to *S. romanica* being those from the rivers east of the range of the later species. Based on this similarity, Bănărescu et al. (1972) concluded that the ancestor of *S. romanica* was a subspecies of *S. aurata*, closest to *S. a. vallachica*. Preliminary, unpublished electrophoretic studies of C. Tesio confirm the phyletic affinities between *S. romanica* and *S. a. vallachica*. In the light of this opinion, *S. romaniaca* originated south of the Carpathians and reached the tributaries of the Mureş by means of a river capture either between the headwaters of the Jiu and those of the Strei, tributary of the Mureş, or between some Transylvanian tributary of the Olt and the Sebeş, another tributary of the Mureş.

2. Perdices et al. (in press) consider, using mitochondrial DNA techniques concluded that *S. romanica* and *S. balcanica* (which includes the subspecies formerly in *S. aurata*) are not very closely related, the closest relative of the former species being the Italian *S. larvata*. The group *larvata-romanica* is believed to have an older age than the *balcanica-vallachica* complex. Accepting this opinion, it means that the restricted and disjunct range of *S. romanica* is a relictar, having resulted from the reduction of a formerly much wider one.

Two other species, both endemic to the upper-middle Danube drainage area have restricted ranges in the Tisa Basin: *Rutilus pigus,* recorded only from the lower sectors of the Tur and Someş-Szamos rivers in Hungary and Romania (Bănărescu, 1964; Harka, 1997; fig. 1) and the lamprey *Eudontomyzon vladykovi*, present only in the headwaters of the river Bega, the southernmost tributary of the Tisa (Bănărescu, 1969).

Finally, a species of rudd, *Scardinius racovitzai* is endemic to a small thermal pond in the system of Crişul Repede River, tributary of Tisa. This species is discussed in another paper.

## References


Allardi, J., Keith, P., 1991 - Atlas preliminaire des poisson d'eau douces de France, *Mus.* Ntl. Hist. Nat., Paris, pp: 1- 232;

Antipa, G., 1909 - Fauna ihtiologică a României, Edit. Acad., Bucureşti, pp: 1-294;

Bănărescu, P., 1953 - Contribuţiuni la studiul faunei ihtiologice dulcicole a R. P. Române. *Stud. Cerc. Şt.,* Acad. Română, Filiala Cluj, **4** (1-2), pp: 153- 187;

Bănărescu, P., 1964 - Pisces - Osteichthyes. *Fauna R. P. Române*, **13,** Edit. Acad., Bucureşti, pp: 1-962;

Bănărescu, P., 1969 - Cyclostomata şi Chondrichthyes. *Fauna R.S. România*, **12,** Edit. Acad., Bucureşti, pp: 1-103;

Bănărescu, P., Herzig-Straschil, Barbara, 1998 - Beitrag zur Kenntnis der Leuciscus - Untergattung Telestes Bonaparte (Pisces: Cyprinidae). *Ann. Naturhist. Mus. Wien*, **100 B**, pp: 406-424;

Berg, L.S., 1932 - Übersicht der Verbreitung der Süsswasserfische Europas. *Zoogeographica*, **1**, pp: 107-208;

Bianco, P.G., 1979 - La distruziona del vairone (Pisces, Cyprinidae) in Italia e suo rinvenimento nel fiume Biferno nel Molise. *Bull. Mus. natn. Hist. nat. Paris* (4[e] ser.), sect. A, **3**, pp: 827-832;

Harka, A., 1997 - Halaink. Kepes hatarozo es elterjedesi utmutato. Budapest.

Leiner, S., Popovic, 1984 - Rod Leuciscus (Cyprinidae, Pisces) udama jadranskog sliva sosvrtom na nalaz: *L. svallize* (Heckel i Kner, 1858) i *L. souffia* Risso, 1826 u Cetini. *Ichthyologia*, Beograd, **16** (1-2), pp: 1-1894;

Vladykov, V., 1932 - Les poissons de la Russie sous-carpatique (Tchecoslovaquie). *Mem. Soc. Zool. France*, **29**, pp: 217-374.

P. M. BĂNĂRESCU
Research Institute of Biology
Department of Biosistematics
Splaiul Independenţei 296
79651 Bucureşti
România

# MODIFICATIONS OF THE FISH FAUNA IN THE UPPER TISA RIVER AND ITS SOUTHERN AND EASTERN TRIBUTARIES

*I. C. Telcean and P. M. Bănărescu*

**Abstract**

In the upper Tisa and its main tributaries on the left shore: Vişeu, Iza, Săpânța, Someş, Barcău, Crişul Repede, Crişul Alb, Crişul Negru and Mureş, there were identified a number of 64 fish species and one of lamprey, *Eudontomyzon danfordi*. A number of 54 fish are native species, including an additional endemic species (*Scardinius racovitzai*), and 11 fish species are allochtonous. Some of them have been recolonised in some of the rivers where they were formerly abundant. In the case of many of these species, the data represent the last results of our field research carried out along the rivers (during 1992-2001), pointing out that considerable changes of the ichthyofauna occured. In the last decades we attend to the alarming numerical decrease of the number of fish species, or the range and numerical modifications of fish from some rivers` sections. For the present day a number of 17 native species are undergoing a numerical regression or have become almost extinct, and 8 fish species have been favoured by the modification of the aquatic biotopes. The natural life conditions changed in the river bed, modifying the fish communities, especially in those located downstream to the towns. According to the ecological requirements of the fish species and their adaptive resources, we propose a number of four fish categories, living in many of the studied rivers. The presence of these fish categories along the affected stretches of the rivers represents a measure for the fish fauna changes.

**Keywords:** Fish fauna; Tisa River basin; range and numerical modifications.

## Introduction

The first records about the fish species from the upper Tisa and its main tributaries on the left shore (the Transylvanian basin) belong to Fridvalsky (1767), Benkő (1778) Bielz (1853, 1888), Herman (1887) and Vutskits (1918). The data presented by these authors mentioned the occurence of the fish species from the entire Transylvania and some of the tributaries from Hungary. Many of these authors published those papers without mentioning the localities where they found the fish species. A complete faunistical list with regard to the freshwater fish species from Romanian rivers is published by Bănărescu (1953), and Bănărescu and Müller (1959). They mention a number of 51 fish species from Transylvanian rivers. More details are provided in the monograph of Bănărescu (1964). This is a fundamental work devoted to bony fish from the entire Romania. The earlier data about the fish from the Hungarian section of Someş River and the other tributaries of the Tisa River were published by Heckel and Kner (1858), Vutskits (1904) and Vásárhely (1960). More recently the fish fauna from the Hungarian section of the Tisa rivers` system was mentioned by Harka (1995, 1997, 1999). The recent papers of Nalbant, and Bănărescu et al. (1995, 1997, 1999) concerning the fish fauna of the Tisa River and its main tributaries: Mureş, Someş, Crişul Negru, Crişul Alb, Crişul Repede and Barcău represent the results of the latest field research carried out between the years 1991-1996. The modifications occurred in many of the aquatic habitats in the catchment area of the Tisa basin (i.e. dam lakes, water amount decrease, pollution and euthrophication of flowing and standing water bodies and the owerfishing) have a negative impact on the fish fauna. We attempt to establish the number of species which became extinct or numerically declined in certain river sections and, despite of that, which species are favored by human activities.

## Materials and Methods

The present paper is based on the field investigations carried out during the years 1992 to 2001 in the upper stretch of the Tisa River and its southern tributaries and subtributaries (Vişeu, Vaser, Ruscova, Iza, Mara and Săpânţa). We also investigated the Romanian stretches of the eastern tributaries of the Tisa: Someş, Crişul Repede and its subtributaries Barcău and Ier, Crişul Negru, Crişul Alb, Mureş and its subtributaries, as well as the channels connecting the Rivers Criş near the villages Tărian, Toboliu, Cefa and Homorog, the ponds and oxbows in the Criş basin, the damlake Tileagd, the ponds from Văşad, Andrid, Alceu, Miersig and Apateu and finally the thermal pond of Băile Episcopeşti (formerly Püspök Fürdő) on the rivulet Petea, tributary of the Crişul Repede River.

## Results and Discussions

A number of 64 species of fish and one of lampreys are present in the area under study, 54 species of fishes and the lamprey *Eudontomyzon danfordi* being native and eleven fish being introduced.

According to their abundance and survival capacity, the 55 native species can be ascribed to the following categories:

(a) Ten species are found in small number and seem to have always been rare, a few of them having also undergone a numerical decline or range reduction: *Acipenser ruthenus* (extinct from the middle Someş, surviving in the lower Someş and the Mureş), *Anguilla anguilla*, *Rutilus pigus*, *Idus idus*, *Pelecus cultratus*, *Lota lota*, *Gymnocephalus baloni, Stizostedion volgense* among inhabitants of rivers, *Misgurnus fossilis* and *Leucaspius delineatus* among those of standing waters.

(b) Four species have small or very small ranges, however without having undergone a numerical decline: *Telestes souffia* and *Cottus poecilopus*, confined to the upper Tisa basin, *Sabanejewia romanica*, present only in six south-western tributaries of the Mureş and *Scardinius racovitzai* endemic to the very small thermal pond Băile Episcopeşti.

(c) Sixteen species underwent a numerical decline or reduction of the range, namely:

– four inhabitants of standing water: *Umbra krameri, Tinca tinca, Scardinius erythrophthalmus* and *Carassius carassius;* the latter was some sixty years ago quite abundant in all lakes and ponds, but is now almost totally extinct (it seems that the species is surviving in small number of individuals only in the thermal pond from Băile Episcopeşti, on the lower reach of Crişul Repede River).

– three inhabitants of montane rivers: *Eudontomyzon danfordi, Thymallus thymallus, Hucho hucho*;

– six inhabitants of lower and partially middle sectors of rivers: *Stizostedion lucioperca, Gymnocephalus schraetser, G. cernuus,* both *Zingel* species (*Z. zingel* and *Z. streber*) and especially *Leuciscus leuciscus*, which became extinct from the Someşul Mic and Săpânţa, surviving, with certainty only in the Crişul Repede River.

– three other species inhabiting the hilly and lowland sectors of rivers, but only in the fast flowing water, underwent some local decline or even extinction, but still remained numerous or even quite abundant on long stretches of other rivers: *Alburnoides bipunctatus* (abundant for example in the upper and middle section of the Crişul Alb River), *Gobio kessleri* (quite abundant in the Someş), *G. uranoscopus* (numerous in the rivers Someşul Mare and Lăpuş).

Sixteen other species have not been affected and maintained their former ranges and abundance, or underwent only a slight decline:

– four inhabitants of montane rivers: *Salmo trutta, Cottus gobio, Phoxinus phoxinus,* and *Barbus peloponnesius petenyi;*

– one species lives in the submontane and lowland sectors of rivers: *Sabanejewia balcanica*;

– eleven inhabitants of lowland rivers and standing waters: *Esox lucius, Alburnus alburnus, Blicca bjoerkna, Abramis brama, A. sapa, Aspius aspius, Rhodeus sericeus, Barbus barbus, Cyprinus carpio, Cobitis* af. *taenia* and *Silurus glanis;*

(d) Nine species have been favoured by human activities, increased their number, partially also extended their ranges: *Squalius cephalus, Rutilus rutilus, Chondrostoma nasus, Abramis ballerus, Vimba vimba, Gobio gobio, G. albipinnatus, Orthrias barbatulus,* and *Perca fluviatilis.*

Changes in the habitat have modified the fish communities and the relative abundance of the species, especially downstream to towns. On the base of the ecological requirements of the species and reaction to modifications of the habitat, four unsharply delimited categories of fish species can be accepted:

(I) **Specialized fish species**, each typical for a habitat:

– *Salmo trutta, Thymallus thymallus,* both *Cottus* species (*C. gobio* and *C. poecillopus*), *Barbus peloponnesius petenyi, Telestes souffia,* in montane sectors of rivers;

– *Chondrostoma nasus, Barbus barbus, Vimba vimba, Aspius aspius, Gymnocephalus baloni, G. schraetser,* in lowland rivers;

– *Ciprinus carpio, Blicca bjoerkna,* the three *Abramis* species (*A. brama, A. sapa* and *A. balerus*), *Esox lucius, Silurus glanis, Gymnocephalus cernuus, Stizostedion lucioperca,* from the lowland and standing waters;

– *Umbra krameri* and *Leucaspius delineatus* in standing waters;

– *Scardinius racovitzai* only in thermal waters.

(II) **Sensitive species**- again specialized to a certain habitat, but also not tolerant to water pollution and other major modifications of the habitat:

– *Eudontomyzon danfordi* and *Thymallus thymallus* in montane sectors of rivers;

– *Gobio uranoscopus* in submontane and partially in the middle sectors of rivers;

– *Sabanejewia romanica* in submontane and partially in the lowland sectors of rivers;

– *Gobio kessleri, Sabanejewia balcanica, Alburnoides bipunctatus* and both *Zingel* species in lowland sectors of rivers with rapidly flowing water;

– *Gobio albipinnatus, Idus idus, Rhodeus sericeus, Gymnocephalus baloni,* and *G. schraetser* in sectors of rivers with slowly flowing water;

– *Scardinius erithrophthalmus* in stagnant water.

Most of these species underwent a numerical decline, except *Gobio albipinnatus* which increased its number and extended its range.

(III) **Rare species:**

– *Anguilla anguilla* and *Lota lota* –in all sectors of rivers, but everywhere in a small number;

– *Hucho hucho* in montane rivers;

– *Leuciscus leuciscus* in hilly and lowland rivers;

– *Acipenser ruthenus* and *Rutilus pigus* in lowland rivers;

– *Carassius carassius* and *Misgurnus fossilis* in stagnant water.

(IV) **Ubiquitous and tolerant or opportunistic species**- tolerate a moderate degree of water pollution and living in several habitats: *Squalius cephalus, Rutilus rutilus, Alburnus alburnus, Gobio gobio, Orthrias barbatulus, Cobitis* af. *taenia,* and *Perca fluviatilis.*

The impact of human ativities on the fish fauna in the various rivers in north-western and western Romania is not the same. The Tisa and its tributaries are the only rivers in western Romania in which *Hucho hucho*, *Telestes souffia* and *Cottus poecilopus* are native. The negative influence of human activities is reduced, compared to other areas of the Tisa River basin; nevertheless, *Telestes souffia* and especialy *Hucho hucho* underwent a numerical decline.

The various components of the Someş River draining area have undergone different human influences. The Someşul Mare and its tributaries have not been affected; the Someşul Mic is strongly polluted downstream the town of Cluj; the upper sector of the united Someş (downstream the town Dej) is partially polluted, but the middle and lower sectors of the river are slightly affected and some sensitive fish species maintain their presence. Downstream of the confluence with the tributary river Lăpuş, the Someş River becomes slightly polluted, but only on a short sector. The species *Rutilus pigus* is confined to the lower sectors of the Someş Rivers and its tributary, the Tur in both Romania and Hungary. The proportion of the four ecological categories of fish species which live in the middle and lower Someş River showed that the ubiquitous and opportunistic species prevail (fig.1). The sensitive fish species have a lower percentage. The specialized fish species from the lowland rivers are represented by *Chondrostoma nasus*, *Barbus barbus, Vimba vimba, Esox lucius* and *Silurus glanis*.

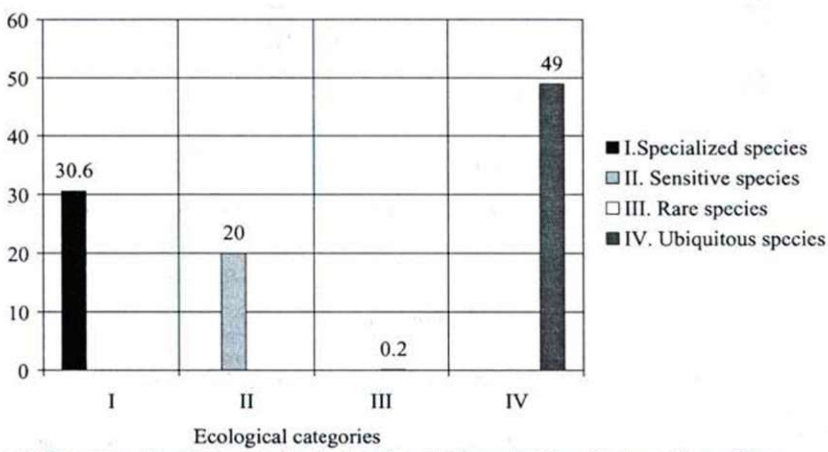



**Figure 1. The proportion of the ecological categories of fish species from the lower Someş River**

The components of the Criş River drainage have been variously affected, too. The Barcău River suffered both from pollution and reduction of the water discharge; *Leuciscus leuciscus* and *Zingel streber* became extinct, at least in the Romanian sector, *Gobio kessleri, Sabanejewia aurata, Gymnocephalus schraetser,* formerly numerous (1953-1964), are presently very rare. The situation of the three Criş rivers is better; Crişul Repede is the only river in Romania in which *Leuciscus leuciscus* and *Stizostedion volgense* still survive; Crişul Negru is the only river in which *Zingel zingel* retains its number; the same river and the Crişul Alb being, besides the Nera, the only rivers in which *Z. streber* is still relatively abundant. *Scardinius racovitzai* is endemic to a thermal pond in the basin of Crişul Repede.

The Mureş River and its tributaries, especially the Arieş and the Ampoi, then the lower sector of the Cerna (Hunedoara county), partially the Târnava Mare are the rivers of the Tisa basin that are most strongly affected by pollution and other human activities. The proportion of the four ecological categories of fish species from the Mureş River reflects the prevailing of ubiquitous and opportunistic species. Both categories of the sensitive and rare fish species are represented by a minimal percentage (fig.2).

Many rheophylic fish species became extinct, or at least underwent a strong numerical decline in long sectors of these rivers.

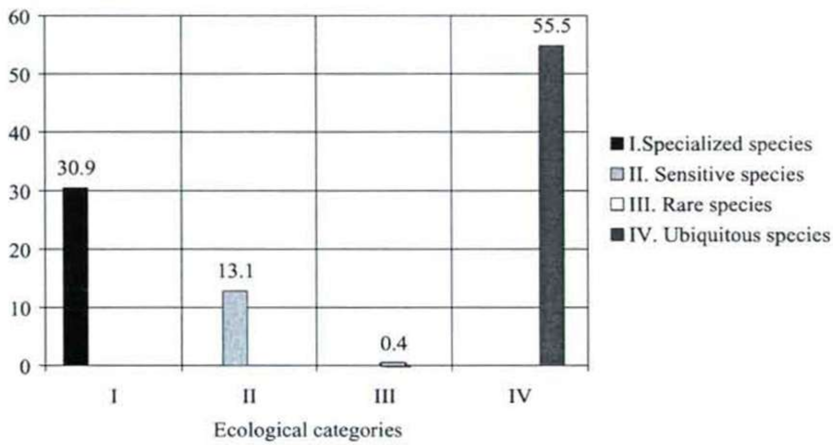



**Figure 2. The proportion of the ecological categories of fish species from the main channel of the Mureş River**

## References


Bănărescu, P., 1964. Pisces-Osteichthyes. Fauna R.P.R. XIII, Edit. Acad., Bucureşti, 962 pp.

Bănărescu, P., 1994. Der gegenwärtige Stand der Fischfauna Siebenbürgens. Naturwissen. Forsch. üb. Siebenbürgen., 5: 257-258. Böhlau Verl., Köln, Weimar, Wien.

Bănărescu, P., 1994. The present day conservation status of the freshwater fish fauna of Romania, Ocrot. nat. med. înconj., 38 (1):5-20.

Bănărescu, P., G., Müller, 1960. Peştii Ardealului şi răspândirea lor. Studii. Cercet. Biol. (Cluj) 10: 335-366.

Bănărescu, P., Telcean, I., Bacalu, P., Akos, H & Sandor, W., 1997. The fish fauna of the Criş / Körös river basin. In: Sárkány-Kiss, A., & J., Hamar, Eds. The Criş / Körös Rivers' Valleys. Tiscia monograph series, Szolnok –Szeged -Tg. Mureş: 301/325.

Bănărescu, P., I., Telcean, T. Nalbant, H., Akos, & W., M. Ciobanu, 1999, The fish fauna of the River Someş/ Szamos River Valley, Tiscia Monograph Series, Szolnok-Szeged-Tg. Mureş: 249-268.

Bielz, E., A., 1888, Die Fauna der Wierbelthiere Siebenburgens nach ihren jetzigen Bestande. Vehr. U. Mitth. Siebenb. Ver. Naturwiss., **38**: 15-120.

Harka, A., P., Bănărescu, I., Telcean, 1999. Fish fauna of the upper Tisa. In: J., Hamar, & Sárkány-Kiss, A Eds. The Upper Tisa Valleys. Tiscia monograph series, Szeged: 439-454.

Nalbant, T., 1995. Fish of the Mureş (Maros) River: sistematics and ecology. In The Maros/ Mureş River Valley. Hamar, J., & Sarkany-Kiss, A. (eds.), Szolnok-Szeged-Tg. Mureş: 225-234.

Telcean, I., 1997. Influenţa barajelor şi amenajărilor hidrotehnice asupra ihtiofaunei bazinului Crişurilor. Analele Univ. din Oradea, Fascicula de Biologie, Tom.V, Ed. Univ. Oradea.

Telcean, I., 1997, Repartiţia altitudinală a ihtiofaunei bazinului Crişurilor. Analele Univ. din Oradea, Fascicula de Biologie, Tom.V, Ed. Univ. Oradea.

Vladikov, V., 1931. Poissons de la Russie Sous-Carpathique., (Tchecoslovaquie)., Mem. Soc. Zool. France, **29**: 217-374.

Vutskits, G., 1913. Classis Pisces. In. Fauna Regni Hungariae, Regia Soc. Scient.Natur-Hungarica, Budapest, 42 pp.

I.C. TELCEAN
University of Oradea
Department of Biology
Str.Armatei Române 5
3700 Oradea
România

P. M. BĂNĂRESCU
Research Institute of Biology
Department of Biosistematics
Splaiul Independenţei 296
79651 Bucureşti
România

# THE PREVAILING ANTHROPOGENIC EFFECTS ON CERTAIN SMALLER NORTHWESTERN ROMANIAN RIVERS

*Sándor Wilhelm, Ákos Harka, Zoltán Sallai*

**Abstract**

In the course of the research of Barcău, Crasna and Ier rivers the particular damaging effects of the anthropogenic factors were proved and the indicator role of some fish species came into limelight.

**Keywords:** ichthyofauna, anthropogenic effects, pollution, water draining

## Introduction

The large-scaled common undertaking of the Pro Europa League from Târgu Mureş and Tisza Klub from Szolnok resulted in useful outcomes. Naturally, such a considerable task took sight at larger rivers above all and less attention was drawn to smaller rivers.

During our research we set ourselves the task of doing a detailed fish-faunistic investigation of those rivers which had been studied to a smaller extent or hadn't been studied at all. Thus, in 1997 we investigated the Barcău, in 2000 the Crasna, and in 2001 the Ier. In the course of our work we were able to notice the effects of the anthropogen interference on the fish-fauna.

## Methods

Lengthwise the rivers already mentioned we used electric fishing machines and, where it was possible, pulling fine-holed nets to take samples from the places appointed in advance.

We let the identified fish back into the river. These results we compared with literature data at our disposal which mirror the earlier condition of the rivers, preceeding the anthropogenic effects, or at least, reflect the former conditions of the rivers.

## Results

On the Barcău, on the reaches beneath Suplacu de Barcău, prevail the polluting effects of crude-oil products due to the activity of refineries. According to the head of the water-station in Marghita, the last greater pollution was in 1994. However, the media presents periodically news about pollution in the area and even in the Sălard area there are petroleum derivates in the silt-layer of the shores. The powerful self-purification process is prevented by the communal sewage of Marghita that flows into the river.

The rich fish stock beneath Suplacu de Barcău has been drastically reduced both in quality and quantity due to the mentioned effects (Harka et al., 1998) ( 1st table). At Cohani we were able to collect 8 specimens of 3 species altogether, from these 6 were the representatives of the *Pseudorasbora parva* species that presented generalistic characters; one was the chub *(Leuciscus cephalus )* and one was the schneider *(Alburnoides bipunctatus)*, that might have been carried off from the upper reaches of Suplacu de Barcău.

In the area of Marghita we collected 81 specimens of 7 species. Nevertheless the overwhelming majority were *Pseudorasbora,* while the one piece of mud loach *(Misgurnus fossilis)*, collected from an area which is not home for this species, also demonstrated eutrophication.

On the rolling country reaches from Suplacu de Barcău to Sâniob, this being the area most exposed to pollution, the disappearance or the significant damaging of the species typical to rolling country could be noticed.

We weren't able to collect sand-gudgeon *(Gobio kessleri)* although Bănărescu (1964, 1980/81) still found it. Another species that can be declared extinct is the dace *(Leuciscus leuciscus)*. We had caught the last specimen of this species in 1994 at Sâniob, but during the collection in 1997 we weren't able to find it. The stock of chub *(Leuciscus cephalus)* and bleak *(Alburnus alburnus)* has also thoroughly decreased in number, while the schneider *(Alburnoides bipunctatus)* could not be find at any extent downward Suplacu de Barcău. Of two typically rolling country species, the nose *(Chondrostoma nasus)* disappeared from the most polluted reaches, moreover, lengthwise the region we were able to find only a portion of population. The barbel *(Barbus barbus)* died out on the whole reach. The balcan spined loach *(Sabanejewia aurata)* is also represented only in the upward zone of the main polluting source, then a portion of population is met on the lowest point of the rolling-country zone, where self-purification prevails to a certain extent.

The effects of the draining of the moorland and the shaping of the river bed can be noticed on the Crasna and the Ier. On the Crasna, the moor of Ecedea was drained in the period between 1895-1898 (Újvári, 1972). Thus there were gained 37.000 ha of arable land of which Romania's share is 92.000 ha. Althrough a thorough assessment of the conditions before the draining hadn't been done, Herman (1887) published a few data about the fish fauna of the moor and the Crasna.

If we compare these data with the results of our own research (Harka, Sallai, Wilhelm, 2001), it can be proved that valuable native fish species of the area had disappeared, such as the crucian carp *(Carassius carassius)*, the tench *(Tinca tinca)*, the mud loach *(Misgurnus fossilis)* and the mudminnow *(Umbra krameri)* that is under international protection (2nd table).

On the upper reaches of the Crasna, above Varsolt, there was built a dam and the water-pool made here provides Zalău and Şimleul Silvaniei with water. The effects of the dam on the fish fauna is illustrated in 3rd table. Allthrough we didn't study the fish-fauna of the pool, it was obvious that under the dam the fish-fauna is rather poor; the 7 species being represented by 861 specimens. Nevertheless, 800 specimens of these are represented by 2 species: the perch *(Perca fluviatilis)* and the sunfish *(Lepomis gibbosus)*, which feel themselves well in the small, slowly flowing lake, polluted with the dirt of the water filter sets. There is hardly any water in the river bed downward the barrage, so above Şimleul Silvaniei the bleak *(Alburnus alburnus)* totals half of the 261 specimens of 10 species. The communal polluting effect of Şimleul Silvaniei gives a sewer's character to the reaches of the river that flows through the town. In this manner there are only 11 species, but the common gudgeon *(Gobio gobio)*, which endures well the eutrophic waters, totals almost half of the number of specimens. The moorworld of the valley of the Ier was extinguished by 1970, thus 27.600 ha of land were reclimed in Bihor county (Sabău, 1997). The dug bed of the Ier was limited by dams so the waterflow, which was slow before the shaping of the area, speeded up substantially. The process influenced negatively the stagnophile elements, which were in overwhelming majority up to that time, but favoured the spreading or the rheophile species.

Unfortunately through assessment of the period preceeding the draining hadn't been done. All the data at our disposal results from the occasional collection made between 1968-1990 (Bănărescu et al., 1997). When comparing these data with the results of our regular collections (Wilhelm, Sallai, 2001), we can still draw interesting conclusions (4th table). In the course of our research we weren't able to find it, so we can declare extinct the crucial carp *(Carassius carassius)* and the bream *(Abramis brama)*. The wels *(Silurus glanis)* has also disappeared. However, we put it on our former species-list on the basis of past fishermen's reports. The number of specimens and the number of homes of the mudminnow *(Umbra krameri)* have also decreased substantially. It is particularly prominent that the mud loach *(Misgurnus fossilis)*, which due to the great stock before the draining gave birth to a special kind of fishing along the Ier, has decreased so much nowadays that it is threatened with extinction.

On the other hand, the number of rheophile elements has increased. The dace *(Leuciscus leuciscus)*, the asp *(Aspius aspius)* and the whitefin gudgeon *(Gobio albipinnatus)* have appeared. Moreover, we have found the sand-gudgeon *(Gobio kessleri)* and the stoneloach *(Barbatula barbatula)* on the upper reaches. Interestingly enough, after the draining we collected ruffe *(Gymnocephalus cernuus)*, but in the course of our last study we were able to find the rheophile balon-ruffe *(Gymnocephalus baloni)* instead of it.

**Table 1. The ichthyofauna of the river Barcău**

| Crt nr. | Species | Romania | | | | | | | | | | | Hungary | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | under the spring | Tusa | Sub-cetate | Nuş-falău | Suplacu de Barcău | Cohani | Mar-ghita | Sân-lazăr | Sâniob | Sălard | Roşiori Bihor | Pocsaj | Berettyó-újfalu | Darvas | Szeg-halom |
| 1 | *Eudontomyzon danfordi* | | 1 | | | | | | | | | | | | | |
| 2 | *Anguilla anguilla* | | | | | | | | | | | | | | | + |
| 3 | *Rutilus rutilus* | | | | | | | | 60 | 20 | 150 | 200 | 120 | 200 | 200 | 200 |
| 4 | *Scardinius erythrophthalmus* | | | | | | | | [1] | | | | 110 | 10 | 4 | 20 |
| 5 | *Leuciscus leuciscus* | | | | | | | | | 1 | | | | | | |
| 6 | *Leuciscus cephalus* | | 20 | 80 | 60 | 60 | 1 | 10 | 30 | 15 | 4 | 8 | 100 | 10 | | 3 |
| 7 | *Leuciscus idus* | | | | | | | | | | | | | | | 1 |
| 8 | *Aspius aspius* | | | | | | | | | | | | | | | + |
| 9 | *Leucaspius delineatus* | | | | | 1 | | | | | | | | | | 2 |
| 10 | *Alburnus alburnus* | | | 10 | 20 | 7 | | 3 | 30 | 120 | 10 | 3 | 280 | 100 | 100 | 300 |
| 11 | *Alburnoides bipunctatus* | | 30 | 300 | 35 | 250 | 1 | | | | | | | | | |
| 12 | *Blicca bjoerkna* | | | | | | | | 4 | | 4 | 1 | 3 | 20 | 7 | 10 |
| 13 | *Abramis brama* | | | | | | | | | | | | | | | 2 |
| 14 | *Abramis ballerus* | | | | | | | | | | | | | 1 | | 3 |
| 15 | *Abramis sapa* | | | | | | | | | | | | | | | ? |
| 16 | *Chondrostoma nasus* | | | | 7 | 1 | | | 5 | | | | | | | ? |
| 17 | *Tinca tinca* | | | | | | | | | | | | 2 | | | 10 |
| 18 | *Barbus barbus* | | | | 2 | | | | | | | | | | | + |

**Table 1. (continued)**

| Crt nr. | Species | Romania | | | | | | | | | | | Hungary | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | under the spring | Tusa | Sub-cetate | Nuş-falău | Suplacu de Barcău | Cohani | Mar-ghita | Sân-lazăr | Sâniob | Sălard | Roşiori Bihor | Pocsaj | Berettyó-újfalu | Darvas | Szeg-halom |
| 19 | *Gobio gobio* | | 15 | 100 | 25 | 7 | | 2 | 500 | 30 | 60 | 10 | 5 | | | 1 |
| 20 | *Gobio albipinnatus* | | | | | | | | 2 | 20 | 200 | 300 | 10 | 200 | 100 | 200 |
| 21 | *Pseudorasbora parva* | | | | | | 6 | 60 | 400 | 100 | 6 | 3 | 10 | 2 | 1 | 20 |
| 22 | *Rhodeus sericeus* | | | | 1 | 2 | | | 10 | 60 | 20 | 15 | 150 | 1 | 100 | 800 |
| 23 | *Carassius carassius* | | | | | | | | | | | | | | | ? |
| 24 | *Carassius auratus* | | | | 1 | 1 | | 2 | | 3 | | 1 | 300 | | | 40 |
| 25 | *Cyprinus carpio* | | | | | | | | | | | | 1 | | | 4 |
| 26 | *Barbatula barbatula* | | 150 | 100 | 6 | | | 3 | 40 | | | | 2 | | | |
| 27 | *Misgurnus fossilis* | | | | | | | 1 | | | | | | | | 70 |
| 28 | *Cobitis taenia* | | | 2 | 2 | | | | 6 | 20 | | 2 | 5 | 30 | 8 | 100 |
| 29 | *Sabanaewia aurata* | | | 25 | 10 | 30 | | | | 1 | | | | | | |
| 30 | *Silurus glanis* | | | | | | | | | | | | | | | 2 |
| 31 | *Ictalurus nebulosus* | | | | | | | | | | | | 1 | | 1 | |
| 32 | *Ictalurus melas* | | | | | | | | [6O] | | | | 1 | | | 3 |
| 33 | *Salmo trutta fario* | 30 | 30 | | | | | | | | | | | | | |
| 34 | *Esox lucius* | | | | | | | | 2 | | | | 3 | | | 4 |
| 35 | *Lepomis gibbosus* | | | | | | | | 2 | 2 | | | 1 | 1 | 1 | 5 |
| 36 | *Perca fluviatilis* | | | | | | | | 4 | 3 | 1 | 1 | 3 | 1 | | 5 |

**Table 1. (continued)**

| Crt nr. | Species | Romania | | | | | | | | | | | Hungary | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | under the spring | Tusa | Sub-cetate | Nuş-falău | Suplacu de Barcău | Cohani | Mar-ghita | Sân-lazăr | Săniob | Sălard | Roşiori Bihor | Pocsaj | Berettyó-újfalu | Darvas | Szeg-halom |
| 37 | *Gymnocephalus cernuus* | | | | | | | | | | | | 1 | | | |
| 38 | *Gymnocephalus baloni* | | | | | | | | | | | | | | | 1 |
| 39 | *Stizostedion lucioperca* | | | | | | | | | | | | | | | 1 |
| 40 | *Cottus gobio* | | 40 | | | | | | | | | | | | | |
| 41 | *Hypophthalmichthys molitrix* | | | | | | | | | | | | | | | + |
| 42 | *Hypophthalmichthys nobilis* | | | | | | | | | | | | | | | + |
| 43 | *Ctenopharyngodon idella* | | | | | | | | | | | | | | | + |

Notes: [ ] from the tributaries
+ data from fishermen
? uncertain data

**Table 2. Comparing data regarding the fish fauna of Crasna river**

| Crt. nr. | Species | Herman, 1887 | Eced Moor | Herman, 1887 | Crasna River | Bănărescu, 1964 | Harka, Sallai, Wilhelm, 2001 |
|---|---|---|---|---|---|---|---|
| 1 | *Rutilus rutilus* | | | | | + | + |
| 2 | *Rutilus pigus virgo* | | | | | | ! |
| 3 | *Scardinius erythrophthalmus* | | | | + | + | + |
| 4 | *Leuciscus leuciscus* | | | | | | ! |
| 5 | *Leuciscus cephalus* | | | | + | + | + |
| 6 | *Leuciscus idus* | | | | | | ! |
| 7 | *Aspius aspius* | | | | + | | ! |
| 8 | *Alburnus alburnus* | | | | | + | + |
| 9 | *Alburnoides bipunctatus* | | | | | + | + |
| 10 | *Blicca bjoerkna* | | | | | | + |
| 11 | *Abramis brama* | | | | + | | + |
| 12 | *Chondrostoma nasus* | | | | | | ! |
| 13 | *Tinca tinca* | | + | | + | + | |
| 14 | *Barbus barbus* | | | | | | ! |
| 15 | *Barbus petenyi* | | | | | | + |
| 16 | *Gobio gobio* | | | | | + | + |
| 17 | *Gobio albipinnatus* | | | | | + | + |
| 18 | *Pseudorasbora parva* | | | | | + | + |
| 19 | *Rhodeus sericeus* | | | | | + | + |
| 20 | *Carassius carassius* | | + | | + | | |
| 21 | *Carassius auratus* | | | | | + | + |
| 22 | *Cyprinus carpio* | | | | + | + | |
| 23 | *Barbatula barbatula* | | | | | | + |
| 24 | *Cobitis taenia* | | | | | + | + |
| 25 | *Misgurnus fossilis* | | + | | | | |
| 26 | *Silurus glanis* | | | | + | | ! |
| 27 | *Ictalurus nebulosus* | | | | | [+] | + |
| 28 | *Ictalurus melas* | | | | | | + |
| 29 | *Umbra krameri* | | + | | | | |
| 30 | *Esox lucius* | | + | | + | + | ! |
| 31 | *Lota lota* | | | | + | | ! |
| 32 | *Lepomis gibbosus* | | | | | | + |
| 33 | *Perca fluviatilis* | | + | | + | + | + |
| 34 | *Gymnocephalus cernuus* | | | | | [+] | |

Notes: + present
[+] maybe present
! only on Hungarian reaches

**Table 3. The ichthyofauna of the Crasna**

| Crt nr. | Species | Romania | | | | | | | | | | Hungary | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cizer | Horoatu Crasnei | Varsolt | Şimleul Silvaniei | Săr-măşag | Supuru de Sus | Acăs | Crai-dorolt | Moftinu Mare | Berveni | Vallaj | Kocsord | Vásáros-namény |
| 1 | *Rutilus rutilus* | | 3 | | 4 | | 30 | 30 | 60 | 90 | 150 | 30 | 50 | 25 |
| 2 | *Rutilus pygus virgo* | | | | | | | | | | | | 2 | |
| 3 | *Scardinius erythrophthalmus* | | | | | | 1 | | 2 | 5 | 15 | | | |
| 4 | *Leuciscus leuciscus* | | | | | | | | | | | 2 | | |
| 5 | *Leuciscus cephalus* | 15 | 100 | 1 | 35 | 200 | 100 | 80 | 70 | 40 | 6 | 25 | 20 | 100 |
| 6 | *Leuciscus idus* | | | | | | | | | | | 3 | | 10 |
| 7 | *Aspius aspius* | | | | | | | | | | | 1 | | 6 |
| 8 | *Alburnus alburnus* | 50 | 50 | 40 | 150 | 100 | 100 | 100 | 150 | 150 | 170 | 25 | 70 | 300 |
| 9 | *Alburnoides bipunctatus* | | | | | | | 1 | 10 | 10 | | | | 1 |
| 10 | *Blicca bjoerkna* | | | | | | 3 | 7 | 15 | 80 | 70 | 3 | 1 | |
| 11 | *Abramis brama* | | | | 1 | | 1 | | 1 | 1 | 20 | | | |
| 12 | *Chondrostoma nasus* | | | | | | | | | | | | | 4 |
| 13 | *Barbus barbus* | | | | | | | | | | | | | 30 |
| 14 | *Barbus petenyi* | 15 | 60 | | | 6 | 1 | 1 | | | | | | |
| 15 | *Gobio gobio* | 1 | 20 | | 1 | 300 | 60 | 50 | 25 | 4 | 1 | 10 | | 30 |
| 16 | *Gobio albipinnatus* | | | | | 30 | 10 | 20 | 40 | 10 | 1 | | | |
| 17 | *Pseudorasbora parva* | | | 5 | | 2 | 2 | 2 | 4 | 10 | 1 | | | |
| 18 | *Rhodeus sericeus* | | | 5 | 3 | 6 | | 30 | 100 | 100 | 300 | 150 | 900 | 100 |
| 19 | *Carassius auratus* | | | | | | 12 | 3 | 40 | 15 | 60 | 10 | | 15 |

**Table 3. (continued)**

| Crt nr. | Species | Romania | | | | | | | | | | Hungary | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cizer | Horoatu Crasnei | Varsolt | Şimleul Silvaniei | Sărmăşag | Supuru de Sus | Acăs | Craidorolt | Moftinu Mare | Berveni | Vallaj | Kocsord | Vásárosnamény |
| 20 | *Barbatula barbatula* | 300 | 40 | | 5 | 3 | | 1 | | | | | | |
| 21 | *Cobitis taenia* | | 10 | 10 | 30 | 30 | 60 | 25 | 50 | 150 | 130 | 4 | 6 | 50 |
| 22 | *Silurus glanis* | | | | | | | | | | | | | 3 |
| 23 | *Ictalurus nebulosus* | | | | | | | | 2 | | 2 | | | |
| 24 | *Ictalurus melas* | | | | | | 1 | | | | 3 | | | |
| 25 | *Esox lucius* | | | | | | | | | | | | 1 | |
| 26 | *Lota lota* | | | | | | | | | | | | | 2 |
| 27 | *Lepomis gibbosus* | | | 300 | 2 | 1 | | | 1 | | 2 | | | |
| 28 | *Perca fluviatilis* | | 6 | 500 | 30 | 1 | | | | | | | | |

Table 4. Comparing data regarding the fish fauna of Ier river

| Crt.nr. | Species | Banarescu et al., 1997 | Wilhelm, Sallai, 2001 |
|---|---|---|---|
| 1 | *Umbra krameri* | + | + |
| 2 | *Esox lucius* | + | + |
| 3 | *Rutilus rutilus* | + | + |
| 4 | *Scardinius erythrophthalmus* | + | + |
| 5 | *Leuciscus cephalus* | + | + |
| 6 | *Leuciscus leuciscus* | | + |
| 7 | *Leucaspius delineatus* | + | + |
| 8 | *Aspius aspius* | | + |
| 9 | *Alburnus alburnus* | + | + |
| 10 | *Blicca bjoerkna* | + | + |
| 11 | *Abramis brama* | + | |
| 12 | *Rhodeus sericeus* | + | + |
| 13 | *Gobio gobio* | + | + |
| 14 | *Gobio albipinnatus* | | + |
| 15 | *Gobio kessleri* | | + |
| 16 | *Pseudorasbora parva* | + | + |
| 17 | *Cyprinus carpio* | + | + |
| 18 | *Carassius carassius* | + | |
| 19 | *Carassius auratus* | + | + |
| 20 | *Tinca tinca* | + | + |
| 21 | *Barbatula barbatula* | | + |
| 22 | *Misgurnus fossilis* | + | + |
| 23 | *Cobitis taenia* | + | + |
| 24 | *Silurus glanis* | + | |
| 25 | *Ictalurus nebulosus* | + | + |
| 26 | *Ictalurus melas* | | + |
| 27 | *Perca fluviatilis* | + | + |
| 28 | *Gymnocephalus cernuus* | + | |
| 29 | *Gymnocephalus baloni* | | + |
| 30 | *Lepomis gibbosus* | | + |

## Conclusions

Fish, as any other organisms living in water, are more at the mercy of the effects that influence the given environmental conditions than the species living on land. Among them, there are only a few generalist species that bear a vast ecological spectrum. During our research the *Pseudorasbora parva* of allochton origin proved to suit this description first of all, and perhaps the common gudgeon *(Gobio gobio)* and the roach *(Rutilus rutilus)*. However, the overwhelming majority of fish species have specialist character, thus they are good indicators of the environmental changes that have occurred. This is all the more valid since the fish suffer not only because of the direct effect of the changes of the abiotic factors, but since the majority of them are on a higher level of the food chain, they experience the effects of the changes on the food organisms and thus also the indirect effect.

As we have seen, the water-technical interferences have a drastic effect that change the quality and quantity of the fish-fauna. So we disapprove the construction of the water pool on the reaches upward Suplacu de Barcău on the Barcău, thus changing the fish fauna of a river reaches that we found close to natural.

As far the Ier is concerned, we made the proposal plan, with necessary reasons, of the backmooring of the area. Nevertheless the competent authorities haven't done further steps since the drafting of the plan. Reducing the chemical pollution, the resettlement of the nose *(Chondrostoma nasus)*, and the barbel *(Barbus barbus)* on the rolling hills reches of the Barcău might be possible if the remaining population have drawn up successfully and survived in the branch rivers. The study of this question figures in our plans for this year, all the more since during the assessment of the fish fauna of the Bistra stream (Wilhelm, 1991) we noticed promising signs. However, it is to be feared that if the waterpool being in construction will have the same effects on the water condition of the Barcău, as the waterpool of Varsolt on the Crasna: the extinction of the remaining population instead of the resettlement of the missing population can't be left out of account.

The upset ecological balance resulting from human interference, the numerous fish populations that have grown weaker or disappeared have created the possibility of the settlement of allochtone species which have occupied the ecological niches that remained vacant. After the German carp *(Carassius auratus)*, the brown bullhead *(Ictalurus nebulosus pannonicus)* and the sunfish *(Lepomis gibbosus)* has appeared the black bullhead *(Ictalurus melas)*, that were first showed in the Ier (Wilhelm, 1998), but we have also found it in the Barcău (Harka et al., 1998) and in the Crasna (Harka, Sallai, Wilhelm, 2001). As a conclusion, the appearance of new fish species can be expected in the foreseeable future.

## References

Bănărescu, P., 1964. *Pisces. Osteichthyes.* Fauna R.P.R., XIII. Ed. Acad., Bucuresti.

Bănărescu, P., 1981. Ihtiofauna bazinului Crişurilor in cadrul general al ihtiofaunei bazinului dunarean. (The Fish Fauna of the Basin of the Criş Rivers within the General Famework of the Danube Basin Fish Fauna). – Nymphaea (Oradea), 8/9: 475/481.

Bănărescu, P., I. Telcean, P. Bacalu, A. Harka, S. Wilhelm, 1997. The fish fauna of the Criş/Körös river basin. /in/ The Criş/Körös Rivers Valleys, Szolnok-Szeged-Târgu Mureş: 3ol/325.

Györe, K., 1995. Magyarorszag termeszetesvizi halai. (The Fishes of Natural Waters of Hungary). Kornyezetgazd. Intezet, Budapest.

Harka, A., 1997. Halaink. (Our Fishes).TKTE, Budapest.

Harka, A., K. Gyore, Z. Sallai, S. Wilhelm, 1998. A Berettyo halfaunaja a forrastol a torkolatig. (The Fish Fauna of the Berettyo from the spring to the mouth).- Halaszat, 91.2, 68/74.

Harka, A., Z. Sallai, S. Wilhelm, 2001. A Kraszna/Crasna halfaunaja. (The Fish Fauna of the Kraszna/Crasna).-Halaszat, 94.l, 34/40.

Herman, O., 1887. A magyar halaszat konyve. (The Hungarian Fishing Book), I-II.-Term.Tud. Konyvkiado, Budapest.

Sabau, N.C., 1997. Impactul lucrărilor hidroameliorative asupra solurilor din perimetrul Valea Ier. (The impact of Hydroameliorative Works on the Soils of the Ier Valley). Ed.Univ., Oradea.

Ujvari,I., 1972. Geografia apelor Romaniei. (Geography of the Waters of Romania.). Ed.Stiint., Bucuresti.

Wilhelm, A., 1987. Tigănuşul *(Umbra krameri* Walbaum*)* în valea Ierului. (The Mudminnow in the Ier Valley).-Crişia (Oradea), XVII, 651/654.

Wilhelm, A., 1998. Black bullhead *(Ictalurus melas* Rafinesque, 1820*) (Pisces: Ostariophysi: Bagridae)* a new Species of Fish Recently Found in Romanian Waters. Trav.Mus.natl.Hist.nat. "Grigore Antipa", XL,377381.

Wilhelm, S., 1998. A fekete törpeharcsa *(Ictalurus melas* Rafinesque, 1820*)* terhoditasa az Er folyo volgyeben. (The Spreading of the Black Bullhead in the Ier River Valley. Muzeumi Fuzetek (Kolozsvar), 7, 110/112.

Wilhelm, A., Z. Sallai, 2001. Fauna ihtiologica a raului Ier.(The Ichthyological Fauna of the Ier River). Satu Mare. Studii si comunicari /in press/.

SÁNDOR WILHELM
RO-3750 Săcuieni, P-ţa Libertăţii 24/7
wilhelms@rdslink.ro

ÁKOS HARKA
Kossuth Lajos Gimnázium
6350 Tiszafüred, Tántits M. u. 1, Hungary

ZOLTÁN SALLAI
Nymphaea Nature Conservation Society, Szarvas
5421 Túrkeve, P.O. Box 33
Hungary

# MAJOR THREATS FOR AMPHIBIAN AND REPTILES SPECIES IN THE TRANSYLVANIAN RIVERS' BASINS. RECOMMENDED MONITORING METHODS

*Mara Gyöngyvér*

**Abstract**

The author tries to identify the major threats for amphibian and reptile species in the Transylvanian rivers' basins. The herpetological investigations were performed during summertime in the hydrographic basins of Crişul Negru, Someş and Olt rivers, in the period 1997-1999. Two monitoring methods were used, occasional findings and information from local people. The most important factor in the decline of herpetofauna from Transylvanian river's basins seems to be the loss of natural habitats. But the author considers that it is the time for quantitative field research, for a better study of herpetofauna conservation status. Finally, a few monitoring methods are proposed.

**Keywords:** Transylvanian rivers, reptile, monitoring methods.

## Introduction

The loss of amphibian and reptiles species is a worldwidely well-known phenomenon. The freshwater organisms, as well as the amphibians, seem to disappear faster than other vertebrate classes (Griffiths & Beebee, 1992). Local and global changes in environmental factors appear to contribute to the decline of amphibians, such as: global climate change, UV radiation, intensive agriculture (use of pesticides), infections (viruses, fungi, parasites), habitat destruction, water pollution, introduction of other species, introduction of fish (managing fishponds). However, it is becoming clear that not all the species are declining and that not one 'global' factor, but various complexes of factors are responsible for the decline in different parts of the world (Vos & Chardin, 1998).

In Romania the national Nature Conservation Law (462/2001) and the Bern Convention (International Convention on the Conservation of European Wildlife) protect the amphibians and reptiles. Unfortunately, in spite of legislation numerous habitats of herpetological importance are threatened or even destroyed. The wetlands are among the most threatened ones. The reduction of these habitats is a worldwide problem, it causes habitat fragmentation and significantly reduces the population's viability.

## Material and methods

The herpetological investigations were performed during summertime in the hydrographic basins of Crişul Negru, Someş and Olt rivers, in the period 1997-1999. The distribution of amphibian and reptile species is better and better investigated in Transylvania (Ghira et al. in press), but we have a significant knowledge deficit regarding population fluctuations. Amphibians are characterized by considerable population size fluctuations during the years that emphasize the importance of long-term studies.

The best period for amphibian and reptile species monitoring is springtime, the reproducing season, when they can be observed in mass. In other periods of the year, amphibian species can be observed sporadically. That's why, two additional monitoring methods were used: occasional findings and information from local people.

The river's basins were divided into three main zones: mountainous, between 800-1800 m; hilly, between 400-800 m; and hillock/plain, between 200-400 m altitude.

## Results

The highest diversity of herpetofauna was observed in the hilly region, closely related to the wide variety of habitats. The number of observed amphibian and reptile species in the mountain zone is decreased in contrast with the hilly region (Ghira, 1997; Mara et al., 1999). The low diversity of herpetofauna in the plain areas is explained by the ecosystem's monotony due to the intensive agriculture. We notice the dominance of *Rana esculenta complex*, *Lacerta agilis* and *Natrix natrix* in every region, while *Bombina variegata* and *Anguis fragilis* appear to be common species of the hilly region. The other amphibian and reptile species seem to be vulnerable, rare or endangered.

We identified the major threats for amphibian and reptile species in the investigated river's basins as follows:

1. Destruction of wetland habitats (the amphibians, due their biphasic life cycle, at least during the breeding season and larval development are closely related to these habitats):
    - Desiccation works, drainage of wetlands (river regularisation works);
    - Transforming backwaters in fishponds, introducing non-native fish species;
    - Intensive agriculture (use of fertilizers and pesticides, mowing)
    - Scorching of reeds, well vegetated adjacent areas.
2. Water pollution, eutrophication.
3. Destruction of rocky ecosystems.
4. Deforestation, forest fires (damaging hibernation sites).



SZTE Egyetemi Könyvtár
SZEGED
3.

5. Road mortality (killing amphibians on their spring migration and reptiles by traffic).

6. Human consume (springtime, in some places frogs are traditionally consumed and collected in mass by local people).

7. Tourism, human brutality (killing snake and lizard species, such as *Anguis fragilis*).

## Discussion

The most important factor in the decline of herpetofauna from Transylvanian river's basins is the loss of natural habitats. The amphibian species are affected by the destruction of reproducing/breeding sites (freshwater ecosystems) and hibernation sites as well (terrestrial ecosystems). The lack of important reptile fauna elements is due to the destruction of rocky ecosystems and deforestation.

The breeding sites (pools, puddles, ponds) of newt species are polluted or even destroyed. In mountain regions the alpine (*Triturus alpestris*) and Carpathian newt (*Triturus montandoni*) is threatened mainly by deforestation and destruction of small temporary pools by the wood-exploitation works (Necas et al. 1997). Anthropogenic effects, as pollution and destruction of springs and streams, cause the low number of spotted salamander (*Salamandra salamandra*). The reduction of suitable habitats causes habitat fragmentation and the isolation of populations. When extinction can no longer be compensated by recolonisation, the population becomes weaker and even extinct.

The same factors cause the reduction of anuran populations. For the fire-bellied toads (*Bombina bombina*) the most important factor is the loss of habitat (Briggs, 1997) as a consequence of river regularisation works. *Bombina bombina, Pelobates fuscus, Hyla arborea* and *Bufo viridis* are declining rapidly in Denmark due to disappearance of ponds (33%), water pollution/eutrophication (30-40%) and fish introduction (Fog, K., 2000).

The common toad (*Bufo bufo*) is threatened mainly by destruction of suitable freshwater and terrestrial habitats, and losses can also be caused by habitat fragmentation by roads. The most run over amphibian corpses belong to this species, because it is the slowest one.

The brown frog species (*Rana arvalis, R. temporaria, R. dalmatina*) - beside the common threats - are consumed by local people. In springtime hundreds of frogs, sometimes common toads are butchered. The populational fluctuation of *Rana dalmatina* in Aeroe (Denmark) was caused partly by intensification of agriculture and partly by climate changes (Briggs, 1997). The intensive agricultural practices, using pesticides and fertilizers, cause water pollution, and in the same time lead to the accumulation of pollutans in the organisms of the whole food chain.

The swamp turtle (*Emys orbicularis*) is threatened mainly by habitat reduction and other anthropogenic interventions. The lizard and snake species are also threatened by habitat destruction (the reduction of rocky ecosystems and deforestation). In the same time, the human brutality and the road traffic cause losses in their populations.

Humans kill adder species (*Vipera berus, Vipera ammodytes*) and *Coronela austriaca* often misidentified as common adder. The slow worm (*Anguis fragilis*) is the only snake-shaped lizard species in the Romanian herpetofauna that is victim of human brutality. Habitat fragmentation and the negative effect of roads also have to be mentioned.

## Conclusions and proposals

During the investigation two additional monitoring methods were used, occasional findings/visual observation and obtaining information from local people. The last method may give information on particular species that were previously recorded in the study area. We consider that it is the time for quantitative field research, for a better study of herpetofauna conservation status.

We propose the following monitoring methods:

1. Line counting method.

It can be performed in habitats or on road by visual observation, and the counting lines always have a fixed length (Masing, 1997). The road transect method is optimal if environmental conditions are optimal, even a single night can provide reliable data on the presence of amphibian species. Besides the breeding migration in spring, the summer migration of juveniles, or autumn migration can be effectively studied (Puky, 2001).

2. Road counting call method.

It was first used as monitoring method in Canada. A relatively straight route consisting of 10 sample points (with 0.5 km distance one from another) without extraneous noise has to be chosen, and is preferably to reflect a variety of good amphibian habitats such as pons, marshes or swamps (Anthony & Puky, 2001).

3. Square counting method.

Is a modification of the quadrate sampling method, described by Jaeger & Inger in 1994, and the counters choose the squares in suitable habitats, where it is expected to find a large number of amphibians and reptiles. The counts are calculated per hectare (Masing, 1997)

4. Trapping methods.

The point counting method (man-made holes) and the cone counting method (digging metal or plastic cones into the ground) also can be used for monitoring actions. Both are in fact close to the pitfall traps method, and can be used selectively for certain species (Masing, 1997).

## References

Anthony, B & Puky, M. (2001): Kétéltűek hang alapján történő monitorozása (Road call count monitoring manual of Hungary), Varangy Akciócsoport Egyesület / Central European University, Budapest.

Briggs, L. (1997): Recovery of Bombina bombina in Funen County, Denmark, Memoranda Soc. Fauna Flora Fennica 73:101-104.

Fog, K. (2000): Amphibian conservation in Denmark, Frolog 13 (on line)

Ghira, I. (1997): Herpetofauna of Crişul Repede/Sebes Körös and Barcău/Berettyó river basins, The Criş/Körös River's Valleys, Tiscia monograph series, 353-360.

Ghira, I., Vencel, M., Covaciu-Marcov, S., Mara, Gyongyver, Ghile, P., Hartel, T., Török, Zs., Farkas, L. Racz, T., Farkas, Z. & Brad, T. (2002): Mapping of Transylvanian herpetofauna (in press)

Griffiths, R.A. & Beebee, T. (1992): Decline and fall of the amphibians, New Scientist, 1826: 25-29.

Mara, Gyöngyvér, Ghira, I. & Farkas, L. (1999): Preliminary report on herpetofauna of the upper and middle Olt river basin, Transylv. Rev. Syst. Ecol. 1:169-181.

Masing, M. (1997): Methods used for monitoring amphibian population in Estonia, Memoranda Soc. Fauna Flora Fennica 73:119-124.

Necas, P., Modry, D. & Zavadil, V. (1997): Czech Recent and Fossil Amphibians and reptiles – An atlas and field guide, Ed Chimaira, Frankfurt am Main.

Puky, M. (2001): Herpetological methods: I. On the use of the road transect method in surveying amphibians with examples from different zoogeographical regions of Hungary, Opusc. Zool. Budapest XXXIII: 75-81.

Vos, C.C. & Chardin, J.P. (1998): Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*, J. of Applied Ecol. 35: 44-56.

GYÖNGYVÉR MARA
Sapientia University
Faculty of Technical and Natural Sciences
Department of Ecology
RO-4100 Miercurea Ciuc
P-ţa Libertăţii 1.

# DISTRIBUTION, POPULATION SIZE AND DYNAMICS OF THE WHITE STORK *(CICONIA CICONIA L.)* IN THE UPPER AND MIDDLE OLT RIVER BASIN (ROMANIA)

*Ferenc Kósa, László Demeter, Tamás Papp, Friedrich Philippi, Hans-Johann Lutsch and Károly György*

**Abstract**

Based on the results of the censuses carried out between 1996-2000, the total population of the Upper and Middle Olt River Basin is 721 HPa distributed in 304 localities. The total population of the region can be estimated to approx. 800 HPa. About 30% of Transylvanian population and about 16% of Romanian population breeds in the study area. From a vulnerability, conservational and monitoring point of view it is important to note that ~10% of the localities hold almost half (328 HPa - 45.49%) of the total breeding population of the whole area. The mean population density (StD) for the whole area was 5.469 HPa/100 $km^2$. Out of a total of 721 breeding pairs, 64% were found to nest at altitudes between 500-1000 m and only 36% nests within the altitudinal belt of 300-500 m. Most common nest sites are electric pylons (45.26%), barns (24.47%) and chimneys (22.48%). Since the 1960-s massive changes have been observed in nest site preferences, from buildings to electric pylons. The mean JZa and JZm values for the Upper and Middle Olt River Basin were above 2.0 and 2.5 in 1998-2000, values which are higher than the estimated JZa and JZm values needed to keep the population stable. The White Stork population of the Middle and Upper Olt River Basin has undergone a continuous decrease from the sixties until the end of the nineties. Positive populational changes can be seen, with the exception of the Făgăraş Basin, only in the *1988/1989-2000* period: the population has recovered to the level of the sixties and is still increasing in the Ciuc, Târgu Secuiesc and Sibiu Basins.

**Keywords:** White Stork, Olt River Basin, distribution, population size, breeding success, colonial nesting, nest site selection, population trends.

## Introduction

The White Stork has been identified as a priority bird species in 4 out of 7 agricultural and grassland habitats of Europe (Tucker and Dixon 1997), and recently it was proposed as a habitat indicator species for agricultural habitats by Tucker *et al.* (2000). The White Stork is a flagship species for the international conservation of wetlands, ecologically valuable river lowlands and low intensity farmland as well as for the conservation of migratory birds in general (Samusenko 2000). Thus conserving the White Stork is an important contribution toward the preservation of biodiversity and consequently to the implementation of the Convention on Biological Diversity (Schulz 1999b).

The White Stork is distributed over the entire territory of Romania and the total number of breeding pairs was estimated by the last national census (1999) to ~ 4500 breeding pairs (Kósa 2001). The first regional White Stork census in this area was conducted between 1909-1915 by Jakab Schenk (Salmen 1980), but more detailed censuses were made only in the second half of the 20$^{th}$ century. Data on the numbers and population trends of the White Stork in the the Middle and Upper Olt River Basin were published by the following authors: Béldi (1962), Damó (1984, 1985, 1994), Demeter (2001a, 2001b), Klemm (1969, 1975a, 1975b, 1983), Klemm and Salmen (1988), Kohl (1980), Kovács (1975, 1976), Kováts (1968a, 1968b, 1974), Molnár (1979, 1981, 1990), Lutsch (1990), Lutsch, Philippi and Popa (1990), Philippi (1997), Philippi (2001), Philippi and Popa (1990b), Popa (1983), Szabó and Papp (1996), Weber and Antal (1978).

The main goal of this study was to locate and characterize the nest sites used by White Storks in the Upper and Middle Olt River Basin. The second aim was to evaluate all the population data essential for the analysis of the White Stork population in the Upper and Middle Olt River Basin to forecast its further population trends (in addition, in the future our databases will make possible further comparative analysis of the different population parameters in this area). The third aim was to elaborate recommendations for the protection of the White Stork populations and stork habitats. Partial results of our study were published by Demeter (2001a, 2001b) and Philippi (2001).

## Material and Methods

Our study was carried out mainly from 1 July to 10 August 2000 when ~80% out of our data were collected in the Upper and Middle Olt River Basin. The other ~20% of the data were counted by the authors between 1996-1999.

The Upper and Middle Olt River Basin occupies the middle part of Romania (the south-eastern corner of Transylvania) and is situated within four counties (Harghita, Covasna, Brasov, Sibiu) along 386 river kilometers. The total size of the Upper and Middle Olt River Basin is 13181 km$^2$ (Ujvári 1972). The geographical range of the area is from 23°40'E to 26°24'E and from 45°24'N to 46°45'N. The Upper and Middle Olt River Basin consists mainly of intramountainous basins surrounded by 1500-2500 m high mountains in the NW, N, E, S and SW parts. Forests cover 35-45% of the territory, the potential White Stork habitats (arable land + pastures + meadows) amount to 50-61% .

The studied territory was subdivided into seven regions (Fig. 1):

1. Ciuc Basin: includes the catchment area of the Olt between the spring and Micfalău;

2. Târgu Secuiesc Basin: includes the catchment area of the Negru River (without the drainage area of the tributary Târlung River), the Casinu Basin and the drainage area of the Olt River between Micfalău and confluence point with the Negru River;

3. Bârsei Basin: also includes the Baraolt Basin;

4. Homoroade Rivers Basin: the hydrological drainage area of the Homoroade rivers;

5. Făgăraş Basin: includes the Olt catchment area between Racoş and the confluence point with the Lotrioara River, without the Homoroade and the Cibin River Basins;

6. Hârtibaciu River Basin: the hydrological drainage area of the Hârtibaciu River;

7. Sibiu Basin: the hydrological drainage area of the Cibin River, without the drainage area of the Hârtibaciu River.

White Stork population parameters were recorded according to the international abbreviations (Schulz 1999a):

HPa – number of pairs occupying a nest, nesting pairs (HPa=HPm+HPo+HPx);

HPm – number of pairs with fledglings;

HPo – number of pairs occupying a nest but without fledgling;

HPx – number of pairs with unknown breeding success;

JZG – total number of fledglings in a defined area per year;

JZa – breeding success, avearage number of fledged young per pair related to all HPa of a defined area (JZG/HPa);

JZm – breeding success, average number of fledged young per pair related to all HPm of a defined area (JZG/HPm);

Std – "Stork density": number of pairs (HPa) per 100 sq km of a defined area.

Data analysis was made with the FileMaker Pro software and the distribution maps were produced with the DMAP software.

## Results and discussion

Distribution, population size and density

The White Stork breeds all over the study area with the exception of high mountainous regions and forested areas. Distribution of breeding pairs (HPa) is presented in Fig. 2. The species was identified in 304 localities (Table 5.). The distribution of the White Stork throughout the area is uneven. It reaches the highest densities in the Ciuc and Târgu Secuiesc Basins, where grasslands are more widespread as compared to other regions.

Based on the results of the censuses carried out between 1996-2000, the total population of the Upper and Middle Olt River Basin is 721 HPa (Table 1. and Table 5.). As about 15% of the region was not covered by the censuses (mainly the small settlements from the mountainous area), the total population is estimated to approx. 800 breeding pairs.

About 30% of Transylvanian population and about 16% of Romanian population breeds in the study area. The percentage of unsuccesful pairs (%HPo) was low in 2000, only 10.017%.

The mean population density (StD) for the whole area was 5.469 HPa/100 km$^2$ (Table 1.). It is higher than the average value for Romania (4.48 HPa/100 km$^2$ - Kósa 2001) and much higher than for the Someş River Basin (2.78 HPa/100 km$^2$ - Kósa, *unpublished results*).

Breeding pairs were found in 100 full 10-km UTM squares and in 3 partial 10-km squares (from a total of 139 full and 7 partial 10-km squares) (Fig. 3). The species distribution thus covers 70.54% of the total area covered by the 146 UTM squares.

While the territory is not a typical stork habitat (Kováts 1968a), White Stork being a lowland grassland bird, the local density of breeding pairs in some places reaches 50 pairs/100 km$^2$ (in the UTM square 35TMM12) (Fig. 3), which is close to the maximal densities in Europe, and one of the highests in Romania.

Although the highest pair densities can now be found in the Ciuc Basin, Kováts (1968a, 1968b) put forward a hypothesis on a relative recent colonization of the Ciuc Basin by White Storks, based on the memories of elderly local people: the first nests appeared as late as during the second half of the 19$^{th}$ century, and spread from South to North. This hypothesis is apparently supported by the breeding data from the Upper and Middle Olt River Basin, published in the ornithological journal Aquila for the period 1906-1910: from a total of 49 "stork villages" only one, Sâncraieni is mentioned from the Ciuc Basin.

Some ringing recoveries also support the hypothesis of Kováts. The White Stork HGB 1257 ringed by Jakab Schenk in 1909 in Hăghig (Bârsei Basin) was recovered after four years in Joseni (Gheorgheni Basin) at a distance of 113 km to the north from the ringing site (Salmen 1980, Cătuneanu 1999). Three White Storks ringed by R. Iacobi in Arini (Bârsei Basin) were recovered later in NE and NW (Cătuneanu 1999; unfortunately the exact details of ringing and recovery places and dates are missing). All these four recoveries suggest a northward movement of some White Storks from the Bârsei Basin.

A gradual decrease in breeding pair density (StD) was found from the Upper Olt River Basin (Ciuc and Târgu Secuiesc Basins StD=7.11-7.68) to the Middle Olt River Basin (StD=4.35-5.97) (Table 1.), probably in close connection with changes in habitat.

Vertical distribution

Out of a total of 721 breeding pairs, 64% were found to nest at altitudes between 500-1000 m and only 36% nests within the altitudinal belt of 300-500 m (Fig. 4). To the best of our knowledge this altitudinal distribution is unique for the Carpathian Basin and probably also for Europe.

Breeding success

The JZa and JZm values, which characterize the breeding success, were calculated only for the year 2000. In this year 579 HPa (500 HPm + 21 HPx + 58 HPo) and 1669 JZG were recorded distributed in 206 localities. The mean JZa and JZm values for the Upper and Middle Olt River Basin were 2.883 and 3.338. The JZa and JZm values needed to keep the population stable are estimated to 2.0 (Burnhauser 1983) and 2.5 (Lakeberg 1995). As it can be seen in Table 1., the JZa values exceed 2.0 and the JZm values 2.5 in every studied region in 2000. Because high JZa and JZm values were registered also in the 1998-1999 period (Demeter 2001a, Kósa 2001 and other not published data), the White Stork population from the Upper and Middle Olt River Basin can be considered as a stable one.

The frequency distribution of brood size in 2000 for the study area was the following (Fig. 5): the percentage of nests with 1 young (HPm1) was 1.96%, HPm2 - 15.19%, HPm3 – 37.25%, HPm4 – 36.52%, HPm5 – 8.57%. Extremely high number of fledglings (6) was recorded for two nests.

Aggregability and colonial nesting

We used the following definition for White Stork colonies: villages with minimum 5 breeding pairs (Guziak and Jakubiec 1996) among which the maximal distance does not exceed 1 km (Chozas *at al.* 1989). White Stork colonies were identified in 31 localities of the Upper and Middle Olt River Basin (Fig. 2. and Table 5.). From a vulnerability, conservational and monitoring point of view it is important to note that ~10% of the localities hold almost half (328 HPa - 45.49%) of the total breeding population of the whole area!

In order to compare quantitatively the aggregability of White Storks in different regions we introduced two parameters:

I – *intensity* of colonial breeding (proportion of breeding pairs nesting in colonies);

F- *frequency* of colonial breeding (proportion of localities with colonies).

As Fig. 6 shows, the intensity (I) and frequency (F) of colonial breeding is the highest in the Ciuc, Sibiu and Târgu Secuiesc Basins. The highest aggregability levels ($I > 55\%$ and $F > 15\%$) thus occur in the regions characterized also with the highest StD values (Table 1.).

JZa and JZm values calculated for the White Stork colonies (JZa=2.899 and JZm=3.302, n=328 HPa) were almost identical with the values for those localities where only 1-4 HPa breeds (JZa=2.861 and JZm=3.387, n=252 HPa). This is in contrast with the findings of Radkiewicz (1989) who noted greater JZa and JZm values for White Storks colonies compared to solitary nests in West Poland.

The largest stork colonies can be found in the localities Cristian (30 HPa) and Sânsimion (27 HPa).

Nest site selection

The most common nest sites in the Upper and Middle Olt River Basin are electric pylons (45.26%), barns (24.47%) and chimneys (22.48%) (Table 2.). The frequency distribution of nest sites for Romania is the following: 69.31% of nests are constructed on electric pylons and 27.40% on buildings (chimneys + barns + roofs) (Kósa 2001). Thus the study area remains behind other regions in Romania as far as the proportion of nests constructed on electric pylons is concerned.

As Table 2. shows, there are regional differences in nest site preferences. The proportion of nests constructed on barns is the highest in the Ciuc and Târgu Secuiesc Basins (34.85-36.69%) and chimneys are preferred as nesting sites in the Bârsei and Sibiu Basins (43.97-54.16%) (Table 2.).

During the last decades massive changes have been observed in nest site preferences, from buildings to electricity pylons. This process differed significantly in various parts of the study area.

44 years ago White Storks in the Târgu Secuiesc Basin placed their nests exclusively on buildings and trees (Béldi 1962). In 1962-1963 Kováts found no nests constructed on electric poles in the Ciuc and Târgu Secuiesc Basins (Kováts 1968a,1968b). Weber and Antal observed in Ciuc Basin in 1973 only nests constructed on buildings and in trees (Weber and Antal 1978). The first White Stork nests placed on electric poles were recorded in the late 1960-es by Dénes Emese in the Târgu Secuiesc Basin (Lemnia). In this region their proportion rapidly increased: from 3.2% in 1978 (Molnár 1979) to 15.6% in 1988 (Molnár 1990) and to 54.28% in 2000.

The situation is different in the Bârsei Basin. In 2000 the proportion of nests constructed on electric poles was still the lowest in the entire region (24.11%). The proportion of nests constructed on electric poles remained below 50% in the Făgăraş and Sibiu Basins and in the Hârtibaci River Basin, too.

The largest proportion of nests constructed on electric pylons can be found in the north and north-west of the area (Ciuc Basin, Homoroade Rivers Basin). The reason for this is most probably that nests built on electric poles spread from north (Gheorgheni Basin) and north-west (Mureş County) to the Ciuc and Homoroade Rivers Basins.

The proportion of nests placed on poles increased in parallel with the decrease of nests placed on buildings (see for example Molnár 1979, 1981). As suitable nesting places on chimneys and barns are becoming less abundant, electric poles probably serve as a substitute.

In the middle of the 1990s, in cooperation with the national electricity company, the installation of artificial nest platforms on electricity poles was begun in Harghita and Covasna counties (Upper Olt River Basin) and until 2000 about 86 poles were equipped with such platforms. No platforms were installed in Braşov and Sibiu counties (Middle Olt River Basin). Consequently, there are still 234 nests in direct contact with electric wires.

Population trends

The Upper and Middle Olt River Basin, considering the available amount of White Stork population data, is one of the most studied areas in Romania. Despite this fact, the summarised data of the former censuses conducted between 1958-2000 cannot be directly compared for studies on population dynamics. Difficulties arise from the fact that during the censuses the sample areas were different and also when they were the same, in different years different localities were included in the monitoring.

To be able to compare the population trends between different regions in a given time period, we divided the whole time interval, based on the available census data, into the following periods: 1962/1963-1973/1974, 1973/1974-1988/1989 and 1988/1989-2000. Only those localities were included in the analyses where census data are available in two consecutive occasions. Despite the problems mentioned above, data obtained in this way provide a reliable basis to estimate simultaneously the long term population changes for the White Stork in the different regions of the Upper and Middle Olt River for a given time period (Table 3.).

The data presented in Table 3. show regional differences in population trends.

Although both in the Upper and Middle Olt River Basins the White Stork population decreased from the sixties to the seventies, this was more pronounced in the Sibiu and Făgăraş Basins (~ -28.3 - -43.82%) than in the Ciuc Basin (~ -10%). Among the causes of the decline Klemm (1983) listed the disappearance of wetlands due to drainage and river regulation following a systematic government plan and structural changes of the human settlements and attitudes with transition to urban building and behaviour.

In the *1973/1974-1988/1989* period the decline of Stork populations continues in all the regions from where census data are available. A clear difference can be seen in population decrease rate between the Upper and Middle Olt River Basins: the values are situated between -1.6 – -14.6% in the Upper Olt River Basin, and between –15.38 - -41% in the Middle Olt River Basin. The Olt River was drastically regulated in the Ciuc Basin in the late 1970-s, early 1980-s. As a result, the water table dropped and floods occur only rarely. The effect on the flora and fauna was dramatic, several species disappeared from the area. Unfortunately White Stork breeding data are lacking between 1973 and 1997 so we do not know in what manner was affected the breeding population in the first years after the river regulation. The Negru River (Târgu Secuiesc Basin) was regulated in 1974 and Kováts (1975) noted a marked drop in the number of breeding pairs in the localities situated along the river.

Positive population changes occured only in the *1988/1989-2000* period: the populations recovered to the level of the sixties and are still increasing in the Ciuc, Târgu Secuiesc and Sibiu Basins. The present positive population trend of the White Stork in Eastern Europe is generally attributed to the crisis in agriculture during the economic transition period, which resulted in a rapid recovery of biological diversity on agricultural landscapes in these countries (Schulz 1999b). Although this statement seems to be true also for Romania, we cannot exclude the possibility that populational increases observed in some regions (e.g. Sibiu Basin) are resulted from the immigration of breeding pairs from the most affected areas (e.g. Făgăraş Basin).

No HPa changes, compared to 1988/1989, took places in the Bârsei Basin.

The only region in the Middle and Upper Olt River Basin where the population decrease continues is the Făgăraş Basin (-20.1%). The Olt River valley from this region was classified as D-degraded in 1994 and remains one of the most polluted and degraded river sectors in the Upper and Middle Olt River Basin.

The breeding White Stork population in the lower sector of the Făgăras Basin was negatively influenced probably also by the presence of some large dam-hydroelectric power station systems (CHE Arpaşu de Jos, CHE Scorei, CHE Avrig, CHE Racoviţa) built between 1970-1990. The population decrease of White Storks in this sector can be seen in Table 4.

## Conclusions

Based on the results of the censuses carried out between 1996-2000, the total population of the Upper and Middle Olt River Basin is 721 HPa distributed in 304 localities. The total population of the region can be estimated to approx. 800 HPa. In only 31 localities breeds about half (328 HPa) of the total breeding population of the area.

The mean population density (StD) for the whole area was 5.469 HPa/100 $km^2$, that is higher than the average value for Romania (4.48 HPa/100 $km^2$). Out of a total of 721 breeding pairs, 64% were found to nest at altitudes between 500-1000 m and only 36% nests within the altitudinal belt of 300-500 m.

Most common nest sites in the Upper and Middle Olt River Basin are electric pylons (45.26%), barns (24.47%) and chimneys (22.48%). Since the 1960-s massive changes have been observed in nest site preferences, from buildings to electric pylons. This process differed significantly in various parts of the study area.

The mean JZa and JZm values for the Upper and Middle Olt River Basin were above 2.0 and 2.5 in 1998-2000, values which are higher than the estimated JZa and JZm values needed to keep the population stable, thus the White Stork population from the Upper and Middle Olt River Basin can be considered as a stable one.

The White Stork population of the Middle and Upper Olt River Basin has undergone a continuous decrease from the sixties until the end of the nineties. Positive populational changes can be seen, with the exception of the Făgăraş Basin, only in the *1988/1989-2000* period: the population has recovered to the level of the sixties and is still increasing in the Ciuc, Târgu Secuiesc and Sibiu Basins.

From a conservational point of view it is necessary to continue the monitoring of the White Stork populations in key sites (localities with more than 5 HPa). As the foreseeable introduction of the EU agricultural policy in Romania will damage White Stork feeding habitats, increasing efforts are needed to protect these regions. The installation of nestplatforms on electric poles must be continued and extended also in the Middle Olt River Basin.

Figure 1. Regional distribution of localities with White Stork nests in 1996-2000 (in brackets the number of localities whith nests in a given region)

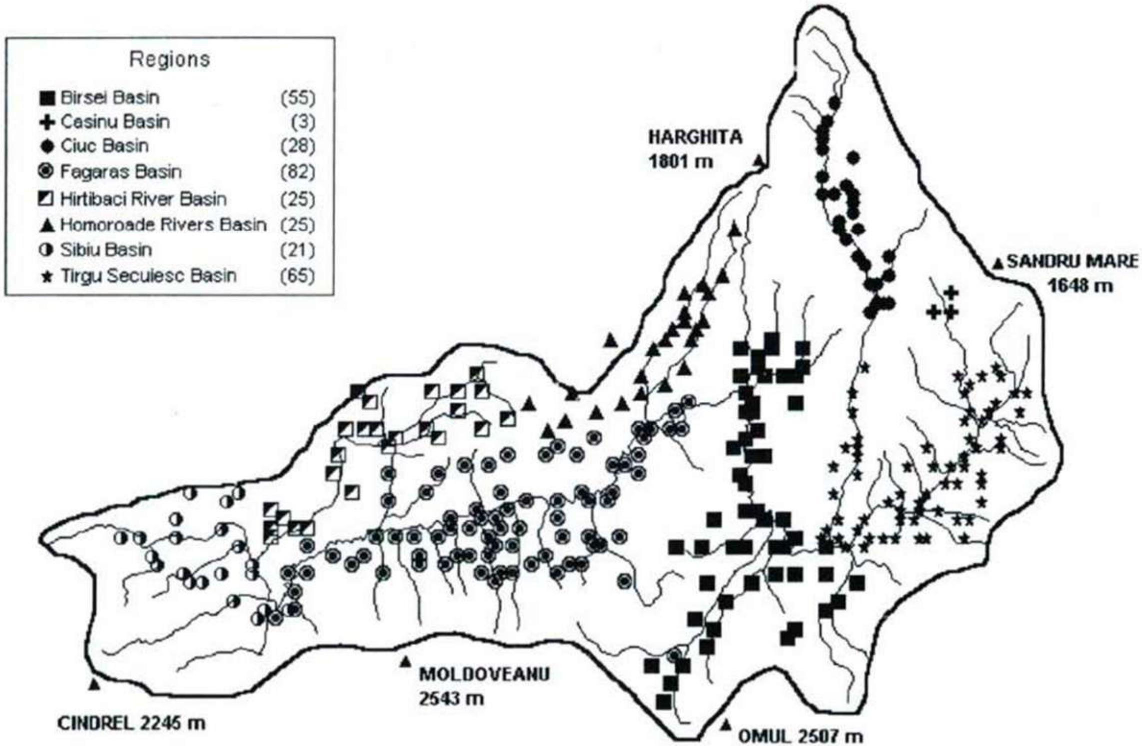
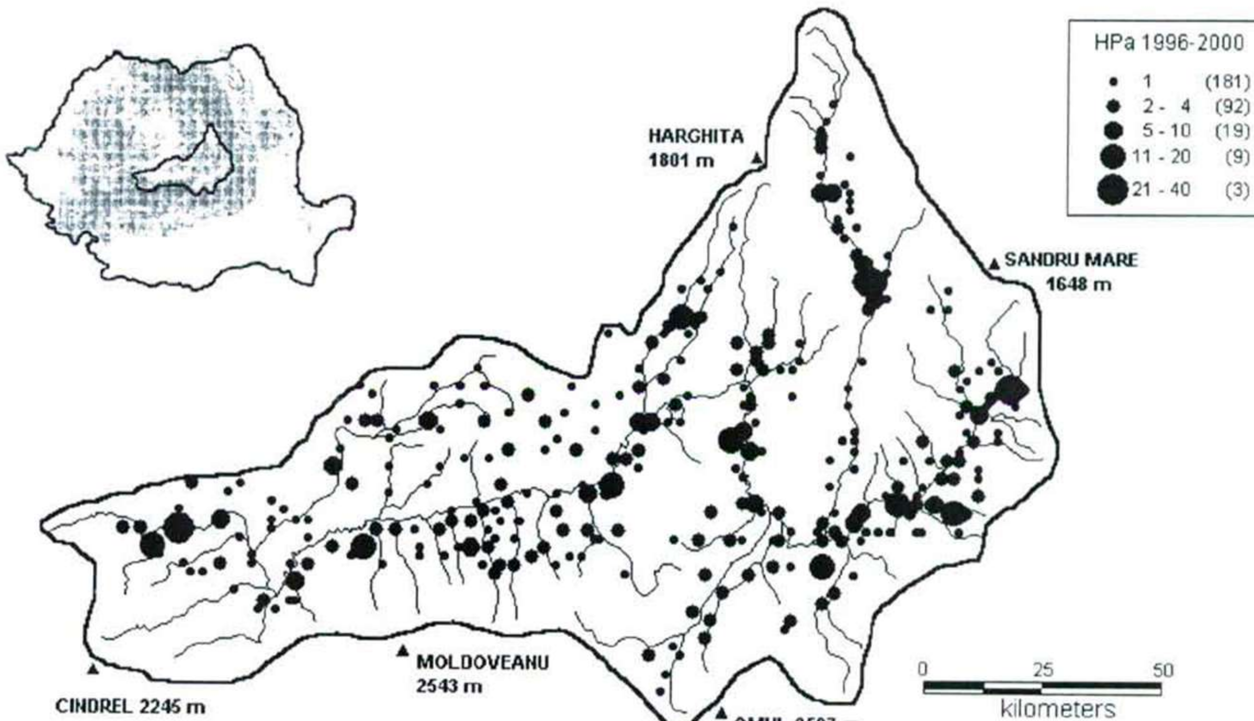


Figure 2. Distribution and number of White Stork breeding pairs (HPa) in the Upper and Middle Olt River Basin (1996-2000)
(Upper left corner: position of the study area in Romania; in brackets the number of localities corresponding to a given HPa range)



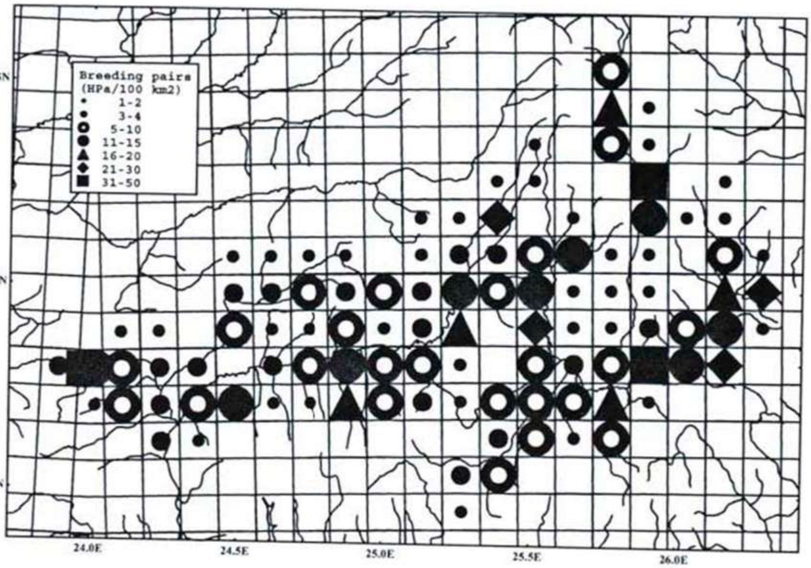



**Figure 3. Distribution of White Stork pair densities (StD=HPa/100 km$^2$) in the Upper and Middle Olt River Basin in 1996-2000 (UTM grid, 10x10 km quadrants)**

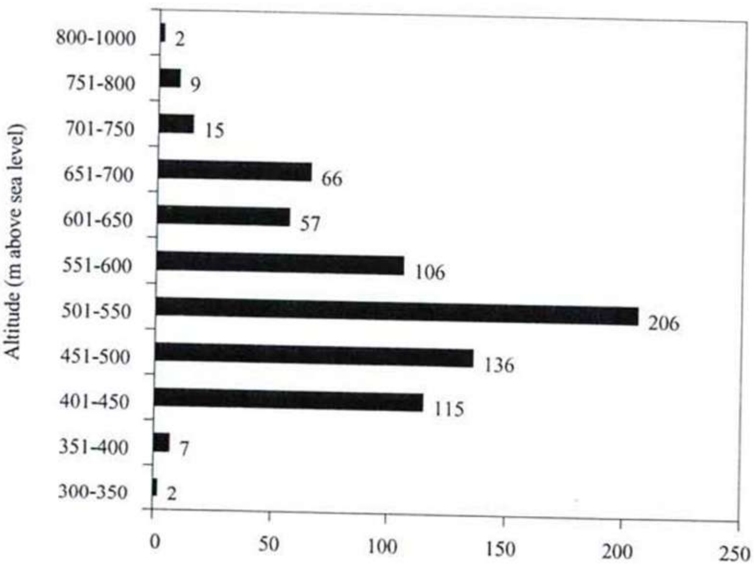



**Fig. 4. Altitudinal distribution of nesting pairs (HPa) in the Upper and Middle Olt River Basin in 1996-2000 (n=721)**

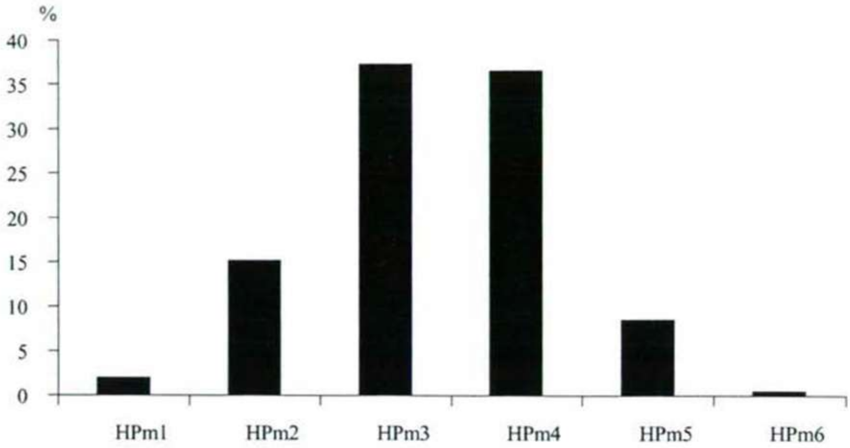



**Fig. 5. The frequency distribution of brood size in the Upper and Middle Olt River Basin in 2000 (n=408 HPm)**

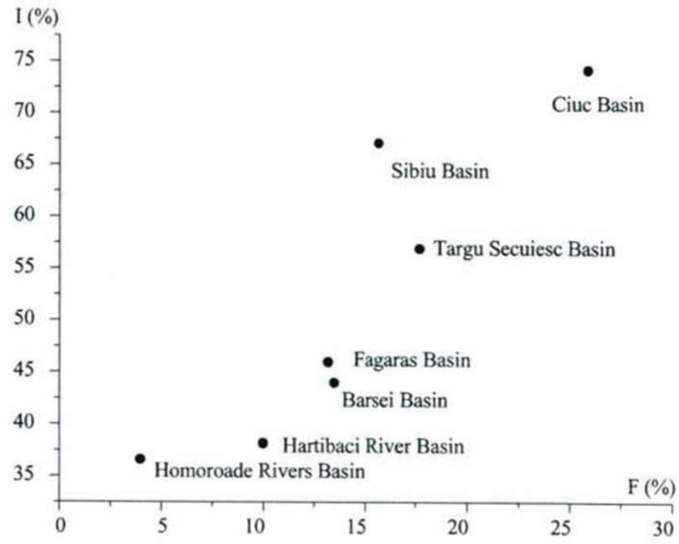



**Fig. 6. Aggregability of breeding White Storks in the Upper and Middle Olt River Basin in 1996-2000 (F - frequency of colonial breeding; I - intensity of colonial breeding)**

**Table 1. Population and breeding parameters of the White Stork in the Upper and Middle Olt River Basin in 1996-2000**

| | Regions | Area ($km^2$) | Nr. of localities with stork nests | H | HPa | HPm | HPo | HPx | HE | uH | JZa* | JZm* | StD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Olt River Basin | Ciuc Basin | 1288 | 28 | 109 | 99 | 79 | 19 | 1 | 1 | 9 | 2.80 | 3.49 | 7.68 |
| | Târgu Secuiesc Basin | 2291 | 68 | 176 | 163 | 127 | 24 | 12 | 6 | 7 | 2.61 | 3.22 | 7.11 |
| | Bârsei Basin | 2760 | 55 | 148 | 133 | 121 | 8 | 4 | 4 | 11 | 2.97 | 3.27 | 4.81 |
| Middle Olt River Basin | Homoroade Rivers Basin | 837 | 25 | 52 | 50 | 42 | 6 | 2 | 0 | 2 | 2.76 | 3.34 | 5.97 |
| | Făgăraş Basin | 3768 | 82 | 175 | 164 | 143 | 13 | 8 | 2 | 9 | 3.01 | 3.40 | 4.35 |
| | Hârtibaci River Basin | 1031 | 25 | 40 | 40 | 39 | 1 | 0 | 0 | 0 | 3.63 | 3.73 | 3.87 |
| | Sibiu Basin | 1206 | 21 | 72 | 72 | 66 | 6 | 0 | 0 | 0 | 2.87 | 3.14 | 5.97 |
| | TOTAL | 13181 | 304 | 772 | 721 | 617 | 77 | 27 | 13 | 38 | 2.883 | 3.338 | 5.469 |

* JZa and JZm values were calculated only for 2000

**Table 2. Distribution of different nest support types of White Stork nests in the Upper and Middle Olt River Basin**

| | Regions | Electric pylon (total) | Electric pylon without support | Electric pylon with support | Chimney | Roof | Barn | Tree | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper Olt River Basin | Ciuc Basin | 62 (56.88%) | 22 (20.18%) | 40 (36.69%) | 4 (3.66%) | 0 | 40 (36.69%) | 3 (2.75%) | 0 | 109 |
| | Târgu Secuiesc Basin | 95 (54.28%) | 71 (40.57%) | 24 (13.71%) | 12 (6.85%) | 3 (1.71%) | 61 (34.85%) | 4 (2.28%) | 0 | 175 |
| | Bârsei Basin | 34 (24.11%) | 29 (20.56%) | 5 (3.54%) | 62 (43.97%) | 12 (8.51%) | 26 (18.43%) | 5 (3.54%) | 2 (1.41%) | 141 |
| Middle Olt River Basin | Homoroade Rivers Basin | 29 (64.44%) | 12 (26.66%) | 17 (37.77%) | 7 (15.55%) | 3 (6.66%) | 3 (6.66%) | 0 | 3 (6.66%) | 45 |
| | Făgăraş Basin | 69 (41.81%) | 69 (41.81%) | 0 | 41 (24.84%) | 5 (3.03%) | 43 (26.06%) | 6 (3.63%) | 1 (0.6%) | 165 |
| | Hârtibaci River Basin | 11 (45.83%) | 11 (45.83%) | 0 | 7 (29.16%) | 5 (20.83%) | 0 | 0 | 1 (4.16%) | 24 |
| | Sibiu Basin | 20 (41.66%) | 20 (41.66%) | 0 | 26 (54.16%) | 2 (4.16%) | 0 | 0 | 0 | 48 |
| | Total | 320 (45.26%) | (234) (33.09%) | (86) (12.16%) | 159 (22.48%) | 30 (4.24%) | 173 (24.47%) | 18 (2.54%) | 7 (0.99%) | 707 |

**Table 3. Population trends of the White Stork in the Upper and Middle Olt River Basin between 1962-2000 (based on data published by Klemm (1975a, 1975b), Kovács (1976), Kováts (1968a, 1968b), Lutsch (1990), Lutsch, Philippi and Popa (1990), Molnár (1978, 1990), Philippi and Popa (1990), Weber and Antal (1978)) (n – number of compared localities)**

<table>
<tr><th></th><th>1962/63-1973/74</th><th>1973/74-1988/89</th><th>1988/89-2000</th></tr>
<tr><td>Ciuc Basin</td><td>- 9.75 %<br>(1962: 82 HPa→<br>1973: 74 HPa; n=15)</td><td colspan="2">+ 14.86 %<br>(1973: 74 HPa → 2000: 85 HPa; n=15)</td></tr>
<tr><td rowspan="2">Târgu Secuiesc Basin</td><td rowspan="2">- 26 %<br>(1963: 92 HPa →<br>1974: 68 HPa; n=21)</td><td>- 1.6 %<br>(1974: 123 HPa →<br>1988: 121 HPa; n=41)</td><td>+ 15.7 %<br>(1988: 121 HPa →<br>2000: 140 HPa; n=41)</td></tr>
<tr><td colspan="2">+ 11.38 %</td></tr>
<tr><td rowspan="2">Bârsei Basin</td><td rowspan="2">- 26.8 %<br>(1963: 41 HPa →<br>1974: 30 HPa; n=13)</td><td>- 14.6 %<br>(1974: 89 HPa →<br>1988/1989: 76 HPa; n=28)</td><td>0 %<br>(1988/1989: 85 HPa<br>→ 2000: 85 HPa;<br>n=32)</td></tr>
<tr><td colspan="2">- 17.98 %<br>(1974: 89 HPa → 2000: 73 HPa; n=28)</td></tr>
<tr><td rowspan="2">Homoroade Rivers Basin</td><td>-</td><td>-</td><td>+ 12.5 %<br>(1989: HPa 8 →<br>2000: 9 HPa; n=7)</td></tr>
<tr><td colspan="3">- 9.09 %<br>(1962: 22 HPa → 2000: 20 HPa; n=7)</td></tr>
<tr><td rowspan="2">Hârtibaciul River Basin</td><td rowspan="2">-</td><td>- 41.17 %<br>(1974: 34 HPa →<br>1989: 20 HPa; n=12)</td><td>+ 25 %<br>(1989: 20 HPa →<br>2000: 25 HPa; n=12)</td></tr>
<tr><td colspan="2">- 26 %</td></tr>
<tr><td>Făgăraş Basin</td><td>- 43.82 %<br>(1963: 89 HPa →<br>1974: 50 HPa; n=5)</td><td>- 23.68 %<br>(1974: 38 HPa →<br>1989: 29 HPa; n=3)</td><td>- 20.17 %<br>(1989: 114 HPa →<br>2000: 91 HPa; n=37)</td></tr>
<tr><td rowspan="2">Sibiu Basin</td><td rowspan="2">- 28.3 %<br>(1963: 74 HPa →<br>1974: 53 HPa; n=11)</td><td>- 15.38 %<br>(1974: 52 HPa →<br>1989: 44 HPa; n=11)</td><td>+ 38.63 %<br>(1989: 44 HPa →<br>2000: 61 HPa; n=11)</td></tr>
<tr><td colspan="2">+ 17.3 %</td></tr>
</table>

**Table 4.: The population decrease of White Stork in the lower sector of the Făgăraş Basin (based on data published by Klemm (1975b), Philippi and Popa (1990))**

| Locality | 1963 | 1974 | 1989 | 2000 |
|---|---|---|---|---|
| Avrig | 12 | 6 | 7 | 2 |
| Racoviţa | 16 | 12 | 11 | 6 |
| Săcădate | 18 | 11 | 0 | 1 |
| Scorei | 42 | 20 | 11 | 11 |
| Total | 88 | 49 | 29 | 20 |

**Table 5. List of localities with White Stork nests in the Upper and Middle Olt River Basin in 1996-2000 (Abbreviations: counties: BV - Brașov, CV- Covasna, HR - Harghita, SB - Sibiu; regions: BIRS - Bârsei Basin, CASI - Cașinu Basin, CIUC - Ciuc Basin, FAGA - Făgăraș Basin, HIRT - Hârtibaci River Basin, HOMO - Homoroade Rivers Basin, SIBI - Sibiu Basin, TSEC- Târgu Secuiesc Basin; Latitude and longitude are expressed in decimal degrees)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGNITA | SB | 45.9667 | 24.6167 | 35TLL19 | 500 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| AITA MARE | CV | 45.9667 | 25.5500 | 35TLL89 | 474 | BIRS | 9 | 7 | 6 | | 1 | | 2 | 21 | 3.00 | 3.50 | 1 | 1 | 2 | | 5 | | | 2000 |
| AITA MEDIE | CV | 45.9833 | 25.5833 | 35TLL99 | 513 | BIRS | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | 1 | | | | 1997 |
| AITA SEACĂ | CV | 46.0333 | 25.6833 | 35TLL99 | 622 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 2000 |
| ALDEA | HR | 46.2500 | 25.4333 | 35TLM72 | 640 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| ALȚINA | SB | 45.9333 | 24.4667 | 35TLL08 | 478 | HIRT | 1 | 1 | 1 | | | | | 1 | 1.00 | 1.00 | | | | | | | | 2000 |
| ANINOASA | CV | 45.8166 | 25.9666 | 35TML17 | 538 | TSEC | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | | | | | 1 | | | 2000 |
| APAȚA | BV | 45.9500 | 25.5167 | 35TLL88 | 506 | BIRS | 15 | 13 | 9 | 4 | | 1 | 1 | 31 | 2.38 | 3.44 | 7 | | 4 | | 3 | | | 2000 |
| APOȘ | SB | 46.0333 | 24.5500 | 35TLM10 | 527 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| ARACI | CV | 45.8167 | 25.6500 | 35TLL97 | 506 | BIRS | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 1 | | | | 1 | | | 2000 |
| ARINI | BV | 45.8833 | 25.5500 | 35TLL88 | 489 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | 1 | | | 2000 |
| ARIUȘD | CV | 45.7833 | 25.6833 | 35TLL97 | 501 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| ARPAȘUL DE JOS | SB | 45.7833 | 24.6167 | 35TLL17 | 400 | FAGA | 2 | 2 | | | 2 | | | | 0.00 | 0.00 | | | 2 | | | | | 2000 |
| AUGUSTIN | BV | 46.0500 | 25.5500 | 35TLM80 | 442 | BIRS | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 1999 |
| AVRIG | SB | 45.7167 | 24.3833 | 35TKL96 | 377 | FAGA | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | 1 | | | | | | | 2000 |
| BĂCEL | CV | 45.7667 | 25.8167 | 35TML06 | 506 | TSEC | 3 | 3 | 2 | | 1 | | | 5 | 1.67 | 2.50 | 3 | | | | | | | 1999 |
| BACIU (SĂCEL) | BV | 45.6000 | 25.6667 | 35TLL95 | 968 | BIRS | 1 | | | | | | 1 | | 0.00 | 0.00 | | | | | | | | 1998 |
| BANCU | HR | 46.3000 | 25.9333 | 35TMM12 | 691 | CIUC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 1998 |
| BARAOLT | CV | 46.0833 | 25.6000 | 35TLM90 | 482 | BIRS | 2 | 2 | 2 | | | | | 9 | 4.50 | 4.50 | 1 | | 1 | | | | | 2000 |
| BĂRCUT | BV | 46.0000 | 24.9167 | 35TLL39 | 581 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| BÂRGHIȘ | SB | 45.9833 | 24.5333 | 35TLL09 | 447 | HIRT | 2 | 2 | 2 | | | | | 9 | 4.50 | 4.50 | | | | | | | | 2000 |
| BÂRZAVA | HR | 46.4333 | 25.8167 | 35TMM04 | 769 | CIUC | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| BĂȚANII MICI | CV | 46.1000 | 25.7000 | 35TLM90 | 518 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | 1 | | | | | | 2000 |
| BĂȚANII MARI | CV | 46.0833 | 25.6833 | 35TLM90 | 515 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| BECLEAN | BV | 45.8333 | 24.9167 | 35TLL37 | 423 | FAGA | 5 | 4 | 4 | | | | 1 | 13 | 3.25 | 3.25 | 3 | | | 1 | 1 | | | 2000 |
| BEIA | BV | 46.1500 | 25.1833 | 35TLM51 | 522 | HOMO | 2 | 1 | 1 | | | | 1 | 2 | 2.00 | 2.00 | 1 | | | | 1 | | | 2000 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELANI | CV | 46.0833 | 26.1833 | 35TMM30 | 591 | TSEC | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| BELIN | CV | 45.9333 | 25.5667 | 35TLL88 | 493 | BIRS | 9 | 9 | 9 | | | | | 36 | 4.00 | 4.00 | 1 | | | | 4 | | | 2000 |
| BELIN VALE | CV | 45.9333 | 25.6000 | 35TLL98 | 591 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | 1 | | | 2000 |
| BERIVOI (MARE) | BV | 45.7333 | 24.9833 | 35TLL46 | 532 | FAGA | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | | | 2 | | | 1996 |
| BIBORȚENI | CV | 46.0833 | 25.6500 | 35TLM90 | 495 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | 1 | | | | | | 2000 |
| BICFALĂU | CV | 45.7667 | 25.8667 | 35TML16 | 565 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | 1 | | | | | | 2000 |
| BITA | CV | 45.8333 | 25.9667 | 35TML17 | 525 | TSEC | 14 | 13 | 13 | | | 1 | | 43 | 3.31 | 3.31 | 3 | | | | 11 | | | 2000 |
| BIXAD | CV | 46.1000 | 25.8667 | 35TMM10 | 663 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | 1 | | | 2000 |
| BOD | BV | 45.7667 | 25.6500 | 35TLL96 | 498 | BIRS | 3 | 2 | 2 | | | | 1 | 8 | 4.00 | 4.00 | | | 2 | 1 | | | | 2000 |
| BODOC | CV | 45.9500 | 25.8500 | 35TML18 | 549 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | 1 | | | 1999 |
| BOGATA OLTEANĂ | BV | 45.9833 | 25.3500 | 35TLL79 | 460 | FAGA | 2 | 1 | 1 | | | | 1 | 2 | 2.00 | 2.00 | 1 | | | | | 1 | | 2000 |
| BOIȚA | SB | 45.6333 | 24.2500 | 35TKL85 | 350 | SIBI | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| BOROȘNEU MARE | CV | 45.8167 | 26.0000 | 35TML27 | 564 | TSEC | 3 | 3 | 3 | | | | | 10 | 3.33 | 3.33 | 3 | | | | | | | 2000 |
| BOROȘNEU MIC | CV | 45.7833 | 26.0167 | 35TML27 | 680 | TSEC | 1 | | | | | 1 | | | 0.00 | 0.00 | 1 | | | | | | | 1997 |
| BRĂDENI | SB | 46.0833 | 24.8333 | 35TLM30 | 520 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| BRADU | SB | 45.7167 | 24.3333 | 35TKL96 | 338 | FAGA | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | | 1 | | | | 2000 |
| BRĂDUȚI | CV | 46.1333 | 25.6167 | 35TLM90 | 509 | BIRS | 2 | 2 | 2 | | | | | 4 | 2.00 | 2.00 | | | 1 | | | 1 | | 2000 |
| BRAN | BV | 45.5167 | 25.3500 | 35TLL74 | 776 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 1996 |
| BRATEȘ | CV | 45.8333 | 26.0667 | 35TML27 | 529 | TSEC | 7 | 6 | 6 | | | | 1 | 19 | 3.17 | 3.17 | 2 | 3 | | | 2 | | | 2000 |
| BREAZA | BV | 45.7000 | 24.8833 | 35TLL36 | 607 | FAGA | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | | | 1 | | 2 | | | 1996 |
| BREȚCU | CV | 46.0500 | 26.3000 | 35TML49 | 592 | TSEC | 4 | 4 | 1 | 2 | 1 | | | 2 | 0.50 | 2.00 | 2 | 2 | | | | | | 2000 |
| BRUIU | SB | 45.8667 | 24.7000 | 35TLL28 | 514 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | 1 | | | | 1999 |
| BUCIUM | BV | 45.7333 | 25.0833 | 35TLL56 | 556 | FAGA | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |
| BUDILA | BV | 45.6667 | 25.8000 | 35TML05 | 581 | BIRS | 2 | 2 | 1 | | 1 | | | 4 | 2.00 | 4.00 | 1 | | | | | 1 | | 2000 |
| CALBOR | BV | 45.8667 | 24.9000 | 35TLL38 | 508 | FAGA | 2 | 2 | 2 | | | | | 6 | 3.00 | 3.00 | 1 | | | | 1 | | | 1996 |
| CĂPENI | CV | 46.0333 | 25.5667 | 35TLL89 | 468 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| CĂRPINIȘ | BV | 45.6500 | 25.7667 | 35TML05 | 597 | BIRS | 3 | 3 | 3 | | | | | 6 | 2.00 | 2.00 | 1 | | 1 | | | | | 1998 |
| CÂRȚA | HR | 46.5333 | 25.7500 | 35TMM05 | 735 | CIUC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CÂRȚA | SB | 45.7833 | 24.5667 | 35TLL17 | 409 | FAGA | 2 | 2 | 1 | 1 | | | | 4 | 2.00 | 4.00 | | | | | | | 1 | 2000 |
| CÂRȚIȘOARA | SB | 45.7167 | 24.5833 | 35TLL16 | 526 | FAGA | 1 | | | | | 1 | | | 0.00 | 0.00 | | | | | | | | 1998 |
| CAȘINU NOU | HR | 46.2000 | 26.0500 | 35TMM21 | 698 | CASI | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1998 |
| CAȘOLȚ | SB | 45.7833 | 24.2833 | 35TKL87 | 405 | HIRT | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| CAȚA | BV | 46.0833 | 25.2667 | 35TLM60 | 442 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | 1 | 2000 |
| CATALINA | CV | 45.9666 | 26.1500 | 35TML39 | 551 | TSEC | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| CERNAT | CV | 45.9500 | 26.0333 | 35TML28 | 554 | TSEC | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | 1 | | | | | 1 | | 1997 |
| CETĂȚUIA | HR | 46.2500 | 25.9000 | 35TMM12 | 662 | CIUC | 12 | 12 | 10 | 2 | | | | 33 | 2.75 | 3.30 | | 7 | | | 5 | | | 2000 |
| CHICHIȘ | CV | 45.7833 | 25.8000 | 35TML07 | 508 | TSEC | 4 | 3 | 3 | | | | 1 | 7 | 2.33 | 2.33 | 3 | | 1 | | | | | 2000 |
| CHIRPĂR | SB | 45.9000 | 24.6000 | 35TLL18 | 481 | FAGA | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | 1 | | | | | 2000 |
| CHIURUȘ | CV | 45.8167 | 26.1500 | 35TML37 | 618 | TSEC | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | | | | | 2 | | | 1997 |
| CIBA | HR | 46.3500 | 25.8000 | 35TMM03 | 664 | CIUC | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| CICEU | HR | 46.4167 | 25.7833 | 35TMM04 | 676 | CIUC | 10 | 10 | 6 | 4 | | | | 21 | 2.10 | 3.50 | 2 | 1 | | | 7 | | | 2000 |
| CINCȘOR | BV | 45.8333 | 24.8333 | 35TLL37 | 406 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| CINCU | BV | 45.9167 | 24.8000 | 35TLL28 | 458 | FAGA | 1 | | | | | 1 | | | 0.00 | 0.00 | | | | | | | | 1998 |
| CIȘNĂDIE | SB | 45.7167 | 24.1500 | 35TKL76 | 472 | SIBI | 4 | 4 | 4 | | | | | 15 | 3.75 | 3.75 | | | | | | | | 2000 |
| CIȘNĂDIOARA | SB | 45.7000 | 24.1000 | 35TKL76 | 693 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| COBOR | BV | 45.9500 | 25.0500 | 35TLL49 | 583 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| CODLEA | BV | 45.7000 | 25.4500 | 35TLL76 | 546 | BIRS | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | 3 | | | | | | | 2000 |
| COLONIA BOD | BV | 45.7667 | 25.6333 | 35TLL96 | 514 | BIRS | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | | | 1 | | | | | 2000 |
| COMANA DE JOS | BV | 45.9167 | 25.2333 | 35TLL68 | 453 | FAGA | 2 | 2 | 2 | | | | | 6 | 3.00 | 3.00 | 1 | | | | 1 | | | 2000 |
| COMANA DE SUS | BV | 45.9000 | 25.2667 | 35TLL68 | 527 | FAGA | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | | | 1 | | | 2000 |
| COPĂCEL | BV | 45.7333 | 24.9833 | 35TLL46 | 532 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | 1 | | | 1996 |
| COȘENI | CV | 45.8167 | 25.8000 | 35TML07 | 515 | TSEC | 1 | | | | | 1 | | | 0.00 | 0.00 | | | | | | | | 1997 |
| COVASNA | CV | 45.8500 | 26.1833 | 35TML37 | 564 | TSEC | 3 | 2 | 2 | | | | 1 | 7 | 3.50 | 3.50 | | | | | 3 | | | 2000 |
| COVEȘ | SB | 45.9833 | 24.5667 | 35TLL19 | 464 | HIRT | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 2 | | | | | | | 1998 |
| COZMENI | HR | 46.2167 | 25.9333 | 35TMM11 | 676 | CIUC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | 1 | | | | | | 2000 |
| CRĂCIUNEL | HR | 46.1833 | 25.4333 | 35TLM71 | 560 | HOMO | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | | 2 | | | | | | 2000 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CRIHALMA | BV | 45.9167 | 25.2000 | 35TLL68 | 437 | FAGA | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 1 | | | | | 1 | | 2000 |
| CRISTIAN | BV | 45.6167 | 25.4667 | 35TLL85 | 624 | BIRS | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 1 | | | | 1 | 1996 |
| CRISTIAN | SB | 45.7833 | 24.0333 | 35TKL67 | 441 | SIBI | 30 | 30 | 26 | 4 | | | | 78 | 2.60 | 3.00 | 14 | | 15 | | | | | 2000 |
| CRIZBAV | BV | 45.8167 | 25.4667 | 35TLL87 | 567 | BIRS | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | | | 2 | | 1 | | | 1996 |
| CUCIULATA | BV | 45.9333 | 25.2667 | 35TLL68 | 558 | FAGA | 3 | 3 | 3 | | | | | 10 | 3.33 | 3.33 | 1 | | 2 | | | | | 1996 |
| DACIA | BV | 46.0167 | 25.1500 | 35TLL59 | 461 | HOMO | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | | | 1 | 2000 |
| DAIA | SB | 45.8000 | 24.2833 | 35TKL87 | 425 | HIRT | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | | | | | | 2000 |
| DĂIŞOARA | BV | 45.9667 | 25.1500 | 35TLL59 | 542 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| DALNIC | CV | 45.9167 | 25.9833 | 35TML28 | 574 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 1997 |
| DĂNEŞTI | HR | 46.5167 | 25.7500 | 35TMM05 | 709 | CIUC | 3 | 2 | 1 | 1 | | | 1 | 3 | 1.50 | 3.00 | 2 | | | | 1 | | | 2000 |
| DEALU FRUMOS | SB | 45.9833 | 24.7000 | 35TLL29 | 526 | HIRT | 7 | 7 | 7 | | | | | 26 | 3.71 | 3.71 | | | 2 | 3 | | | 1 | 2000 |
| DEJANI | BV | 45.7167 | 24.9333 | 35TLL36 | 570 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| DELNIŢA | HR | 46.4167 | 25.8333 | 35TMM14 | 721 | CIUC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| DOBOLII DE JOS | CV | 45.7833 | 25.7500 | 35TML07 | 526 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 1999 |
| DOBOLII DE SUS | CV | 45.7833 | 26.0333 | 35TML27 | 581 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 1997 |
| DOBOŞENI | CV | 46.1167 | 25.5833 | 35TLM90 | 509 | BIRS | 2 | 2 | 2 | | | | | 4 | 2.00 | 2.00 | | | 1 | 1 | | | | 2000 |
| DOPCA | BV | 45.9833 | 25.3833 | 35TLL79 | 527 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| DRĂGUŞ | BV | 45.7500 | 24.7833 | 35TLL26 | 519 | FAGA | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 1999 |
| DRĂUŞENI | BV | 46.1333 | 25.3000 | 35TLM61 | 442 | HOMO | 2 | 2 | 2 | | | | | 9 | 4.50 | 4.50 | | | 1 | 1 | | | | 2000 |
| DRIDIF | BV | 45.8167 | 24.8833 | 35TLL37 | 430 | FAGA | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| DUMBRĂVIŢA | BV | 45.7667 | 25.4333 | 35TLL76 | 520 | BIRS | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | | | 2 | | | 1 | | 1996 |
| ESTELNIC | CV | 46.1000 | 26.2166 | 35TMM30 | 614 | TSEC | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| FĂGĂRAŞ | BV | 45.8500 | 24.9667 | 35TLL47 | 416 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1998 |
| FÂNTÂNA | BV | 45.9667 | 25.2833 | 35TLL69 | 469 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 2000 |
| FELDIOARA | BV | 45.8167 | 25.6000 | 35TLL97 | 494 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | 1 | | | 1996 |
| FELMERU | BV | 45.9333 | 25.0167 | 35TLL48 | 588 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| FILIA | CV | 46.1500 | 25.6167 | 35TLM91 | 522 | BIRS | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | | | 2 | | | | | 2000 |
| GALAŢI | BV | 45.8500 | 24.9667 | 35TLL47 | 416 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GHELINȚA | CV | 45.9500 | 26.2333 | 35TML48 | 614 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 1997 |
| GHIDFALĂU | CV | 45.9000 | 25.8500 | 35TML18 | 547 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 1999 |
| GHIMBAV | BV | 45.6667 | 25.5000 | 35TLL85 | 562 | BIRS | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | 1 | | 1 | | | | 1 | 1996 |
| GRÂNARI | BV | 46.0333 | 24.9667 | 35TLL49 | 514 | HOMO | 4 | 4 | 4 | | | | | 12 | 3.00 | 3.00 | 2 | | 2 | | | | | 1996 |
| GURA RÂULUI | SB | 45.7333 | 23.9833 | 34TGR36 | 545 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| GURA VĂII | BV | 45.7167 | 24.9000 | 35TLL36 | 579 | FAGA | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | 1 | | | | | 1 | | 1999 |
| HĂGHIG | CV | 45.8333 | 25.5833 | 35TLL87 | 506 | BIRS | 7 | 5 | 5 | | | 1 | 1 | 17 | 3.40 | 3.40 | 1 | | | | 6 | | | 2000 |
| HĂLCHIU | BV | 45.7667 | 25.5500 | 35TLL86 | 511 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| HĂLMEAG | BV | 45.8667 | 25.1167 | 35TLL58 | 438 | FAGA | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| HAMBA | SB | 45.8667 | 24.2000 | 35TKL88 | 532 | SIBI | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | 1 | | | | 2000 |
| HĂRMAN | BV | 45.7167 | 25.6833 | 35TLL96 | 525 | BIRS | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| HĂRSENI | BV | 45.7500 | 25.0167 | 35TLL46 | 539 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 1999 |
| HĂTUICA | CV | 45.9333 | 26.1333 | 35TML38 | 552 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | 1 | | | 2000 |
| HERCULIAN | CV | 46.1333 | 25.7000 | 35TLM90 | 581 | BIRS | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| HILIB | CV | 45.9667 | 26.2333 | 35TML49 | 768 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 1997 |
| HOGHIZ | BV | 45.9833 | 25.3000 | 35TLL69 | 490 | FAGA | 7 | 7 | 6 | 1 | | | | 21 | 3.00 | 3.50 | 1 | | 1 | | 5 | | | 2000 |
| HOMOROD | BV | 46.0500 | 25.2667 | 35TLM60 | 431 | HOMO | 2 | 2 | 2 | | | | | 8 | 4.00 | 4.00 | | | 2 | | | | | 2000 |
| HUREZ | BV | 45.8000 | 24.9500 | 35TLL47 | 454 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| IACOBENI | HR | 46.2000 | 26.1000 | 35TMM31 | 736 | CASI | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 1997 |
| IACOBENI | SB | 46.0500 | 24.7167 | 35TLM20 | 467 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | | | | 2000 |
| IAȘI | BV | 45.7667 | 24.9333 | 35TLL37 | 493 | FAGA | 1 | 1 | 1 | | | | | 1 | 1.00 | 1.00 | | | | | 1 | | | 1996 |
| IGHIȘU VECHI | SB | 45.9833 | 24.4833 | 35TLL09 | 497 | HIRT | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| ILIENI | CV | 45.8000 | 25.7667 | 35TML07 | 538 | TSEC | 2 | 2 | 1 | 1 | | | | 3 | 1.50 | 3.00 | 1 | | | | 1 | | | 1999 |
| IMENI | CV | 45.9500 | 26.1667 | 35TML38 | 553 | TSEC | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | 1 | | | | 1 | | | 1997 |
| INEU | HR | 46.5500 | 25.7667 | 35TMM05 | 709 | CIUC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| IONEȘTI | BV | 46.1500 | 25.3333 | 35TLM71 | 517 | HOMO | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 2000 |
| JIBERT | BV | 46.0000 | 25.0667 | 35TLL59 | 503 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| JIGODIN | HR | 46.3333 | 25.8167 | 35TMM03 | 680 | CIUC | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | | | 1 | | | 2000 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JIMBOR | BV | 46.1000 | 25.3833 | 35TLM70 | 557 | HOMO | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| LELICENI | HR | 46.3500 | 25.8500 | 35TMM13 | 720 | CIUC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | 1 | | | 2000 |
| LEMNIA | CV | 46.0500 | 26.2667 | 35TML49 | 590 | TSEC | 25 | 21 | 14 | 6 | 1 | 1 | 3 | 45 | 2.14 | 3.21 | 8 | 10 | | | 7 | | | 2000 |
| LEȚ | CV | 45.8500 | 26.0167 | 35TML27 | 528 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | 1 | | | | 1997 |
| LISA | BV | 45.7167 | 24.8500 | 35TLL36 | 555 | FAGA | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |
| LISNĂU | CV | 45.7833 | 25.8833 | 35TML17 | 576 | TSEC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | 1 | | | 1997 |
| LOVNIC | BV | 45.9833 | 25.0167 | 35TLL49 | 634 | HOMO | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | | | | | | 2000 |
| LUDIȘOR | BV | 45.7667 | 24.8833 | 35TLL37 | 491 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| LUETA | HR | 46.2667 | 25.4833 | 35TLM82 | 634 | HOMO | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| LUNCA CĂLNICULUI | BV | 45.7667 | 25.7667 | 35TML06 | 500 | BIRS | 3 | 2 | 2 | | | | 1 | 6 | 3.00 | 3.00 | 3 | | | | | | | 2000 |
| LUNCA OZUNULUI | CV | 45.8000 | 25.8500 | 35TML17 | 509 | TSEC | 1 | | | | | 1 | | | 0.00 | 0.00 | 1 | | | | | | | 1997 |
| LUNGA | CV | 46.0333 | 26.2167 | 35TML39 | 565 | TSEC | 3 | 3 | 3 | | | | | 10 | 3.33 | 3.33 | 1 | | | | 2 | | | 2000 |
| LUȚA | BV | 45.8000 | 24.9000 | 35TLL37 | 451 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| LUTOASA | CV | 46.0833 | 26.2333 | 35TMM40 | 596 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| MĂDĂRAȘ | HR | 46.5000 | 25.7500 | 35TMM05 | 710 | CIUC | 3 | 3 | 2 | 1 | | | | 7 | 2.33 | 3.50 | 2 | | | | 1 | | | 2000 |
| MĂGHERUȘ | CV | 45.7833 | 25.9167 | 35TML17 | 574 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | | 1 | | 2000 |
| MĂIERUȘ | BV | 45.9000 | 25.5333 | 35TLL88 | 477 | BIRS | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| MĂLINIȘ | BV | 45.7500 | 25.0167 | 35TLL46 | 539 | FAGA | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 2 | | | | | 1996 |
| MALNAȘ | CV | 46.0167 | 25.8333 | 35TML09 | 572 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | 1 | | | 2000 |
| MÂNDRA | BV | 45.8167 | 25.0500 | 35TLL47 | 466 | FAGA | 2 | 2 | 1 | | 1 | | | 3 | 1.50 | 3.00 | 1 | | 1 | | | | | 2000 |
| MĂRCUȘA | CV | 45.9167 | 26.0500 | 35TML28 | 554 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 1997 |
| MĂRGINENI | BV | 45.7167 | 25.0500 | 35TLL46 | 612 | FAGA | 2 | 1 | 1 | | | | 1 | 4 | 4.00 | 4.00 | 1 | | | | | 1 | | 1999 |
| MARPOD | SB | 45.8667 | 24.5000 | 35TLL08 | 502 | HIRT | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | 2 | | | | | | | 2000 |
| MĂRTĂNUȘ | CV | 46.0167 | 26.2833 | 35TML49 | 605 | TSEC | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| MĂRTINENI | CV | 45.9166 | 26.1000 | 35TML38 | 541 | TSEC | 2 | 2 | | | 2 | | | | 0.00 | 0.00 | 1 | | 1 | | | | | 2000 |
| MĂRTINIȘ | HR | 46.2333 | 25.3833 | 35TLM72 | 480 | HOMO | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | 1 | | | | | | 2000 |
| MATEIAȘ | BV | 46.0167 | 25.3667 | 35TLL79 | 452 | FAGA | 3 | 3 | 3 | | | | | 10 | 3.33 | 3.33 | 2 | | 1 | | | | | 2000 |

Table 5. (continued)

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MERCHEAȘA | BV | 46.0667 | 25.3333 | 35TLM70 | 459 | HOMO | 2 | 2 | | | 2 | | | 3 | 1.50 | 0.00 | | | | | | | | 2000 |
| MEREȘTI | HR | 46.2333 | 25.4500 | 35TLM82 | 592 | HOMO | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| MERGHINDEAL | SB | 45.9667 | 24.7333 | 35TLL29 | 481 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | 1 | | | | 2000 |
| MICFALĂU | CV | 46.0500 | 25.8333 | 35TMM00 | 610 | TSEC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 2000 |
| MICLOȘOARA | CV | 46.0167 | 25.5667 | 35TLL89 | 480 | BIRS | 3 | 3 | 3 | | | | | 12 | 4.00 | 4.00 | | 1 | 1 | | 1 | | | 2000 |
| MIERCUREA CIUC | HR | 46.3500 | 25.8000 | 35TMM03 | 664 | CIUC | 2 | 2 | 1 | 1 | | | | 4 | 2.00 | 4.00 | | 1 | | | 1 | | | 2000 |
| MOACȘA | CV | 45.8667 | 25.9667 | 35TML17 | 553 | TSEC | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 2 | | | | | | | 1997 |
| MOECIU | BV | 45.4833 | 25.3333 | 35TLL63 | 978 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 1996 |
| MOHU | SB | 45.7333 | 24.2333 | 35TKL86 | 463 | SIBI | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | | | | 2000 |
| MOVILE | SB | 46.0167 | 24.7833 | 35TLL29 | 525 | HIRT | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | 1 | | | | 1998 |
| NĂDEJDEA | HR | 46.4833 | 25.8333 | 35TMM14 | 770 | CIUC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | 1 | | 2000 |
| NETUȘ | SB | 46.0500 | 24.7833 | 35TLM20 | 486 | HIRT | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| NOCRICH | SB | 45.9000 | 24.4500 | 35TLL08 | 433 | HIRT | 6 | 6 | 6 | | | | | 22 | 3.67 | 3.67 | | | | | | | | 2000 |
| NOUL | SB | 45.8333 | 24.2833 | 35TKL87 | 456 | HIRT | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| NUCET | SB | 45.8000 | 24.3833 | 35TKL97 | 442 | HIRT | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | | | | 1996 |
| OCLAND | HR | 46.1667 | 25.4167 | 35TLM71 | 497 | HOMO | 1 | | | | | | 1 | | 0.00 | 0.00 | | 1 | | | | | | 2000 |
| OHABA | BV | 45.7667 | 25.1500 | 35TLL56 | 470 | FAGA | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |
| OLTENI | CV | 45.9667 | 25.8500 | 35TML19 | 562 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | 1 | | | | | | 2000 |
| OLTEȚ | BV | 45.8000 | 24.7667 | 35TLL27 | 428 | FAGA | 3 | 3 | 3 | | | | | 10 | 3.33 | 3.33 | 3 | | | | | | | 2000 |
| ORĂȘENI | HR | 46.1667 | 25.3500 | 35TLM71 | 466 | HOMO | 2 | 2 | 1 | 1 | | | | 5 | 2.50 | 5.00 | | 1 | | 1 | | | | 2000 |
| ORLAT | SB | 45.7500 | 23.9667 | 34TGR37 | 512 | SIBI | 11 | 11 | 10 | 1 | | | | 31 | 2.82 | 3.10 | 1 | | 4 | 1 | | | | 2000 |
| ORMENIȘ | BV | 46.0167 | 25.5500 | 35TLL89 | 459 | BIRS | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | 1 | | | | | 1999 |
| OZUN | CV | 45.8000 | 25.8500 | 35TML17 | 515 | TSEC | 9 | 9 | 9 | | | | | 27 | 3.00 | 3.00 | 3 | | 1 | 1 | 4 | | | 2000 |
| PACHIA | CV | 45.8167 | 26.1167 | 35TML37 | 540 | TSEC | 22 | 20 | 17 | 2 | 1 | 1 | 1 | 57 | 2.85 | 3.35 | 7 | | | | 14 | 1 | | 2000 |
| PALTIN | BV | 45.7000 | 25.2333 | 35TLL66 | 526 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | 1 | | | 1996 |
| PĂPĂUȚI | CV | 45.7833 | 26.1333 | 35TML37 | 562 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |
| PĂRĂU | BV | 45.8500 | 25.1833 | 35TLL57 | 448 | FAGA | 3 | 3 | 3 | | | | | 7 | 2.33 | 2.33 | 1 | | 1 | | 1 | | | 1998 |
| PĂULENI CIUC | HR | 46.4000 | 25.8333 | 35TMM13 | 738 | CIUC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | | 1 | | 1997 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAVA | CV | 45.8833 | 26.1833 | 35TML38 | 606 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| PELIŞOR | SB | 46.0500 | 24.5167 | 35TLM00 | 541 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| PERŞANI | BV | 45.7833 | 25.2167 | 35TLL67 | 559 | FAGA | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 1 | 1 | | | | 1996 |
| PETENI | CV | 45.9167 | 26.1333 | 35TML38 | 561 | TSEC | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 2 | | | | | | | 1997 |
| PETRENI | HR | 45.7167 | 25.6833 | 35TLM71 | 525 | HOMO | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | 1 | | | 2000 |
| PLĂIEŞII DE SUS | HR | 46.2333 | 26.1000 | 35TMM32 | 725 | CASI | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1997 |
| PODU OLTULUI | BV | 45.7167 | 25.6833 | 35TLL96 | 525 | BIRS | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | | | 1 | | | | | 1999 |
| POIAN | CV | 46.0667 | 26.1500 | 35TMM30 | 593 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 1997 |
| POJORTA | BV | 45.7500 | 24.8667 | 35TLL36 | 516 | FAGA | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 1 | | 1 | | | 1996 |
| POPLACA | SB | 45.7167 | 24.0500 | 35TKL76 | 516 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| PORUMBACUL DE JOS | SB | 45.7500 | 24.4500 | 35TLL06 | 404 | FAGA | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | | | 2 | | | | | 2000 |
| PREJMER | BV | 45.7167 | 25.7667 | 35TML06 | 524 | BIRS | 18 | 14 | 14 | | | 2 | 2 | 44 | 3.14 | 3.14 | 2 | | 10 | 5 | | 1 | | 2000 |
| RACOŞUL DE JOS | BV | 46.0333 | 25.4000 | 35TLL79 | 475 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| RACOŞUL DE SUS | CV | 46.0833 | 25.5333 | 35TLM80 | 479 | BIRS | 2 | 2 | 2 | | | | | 6 | 3.00 | 3.00 | | 1 | 1 | | | | | 2000 |
| RACOVIŢA | SB | 45.6833 | 24.3500 | 35TKL96 | 414 | FAGA | 6 | 6 | 5 | 1 | | | | 16 | 2.67 | 3.20 | 3 | | 1 | | 1 | | | 2000 |
| RACU | HR | 46.4500 | 25.7500 | 35TMM04 | 712 | CIUC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 2000 |
| RAREŞ | HR | 46.2000 | 25.3833 | 35TLM71 | 491 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | 1 | 2000 |
| RĂŞINARI | SB | 45.7000 | 24.0667 | 35TKL76 | 677 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| RÂŞNOV | BV | 45.5833 | 25.4500 | 35TLL74 | 684 | BIRS | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | | 1 | 1 | | | 1996 |
| RECEA | BV | 45.7167 | 24.9333 | 35TLL36 | 570 | FAGA | 2 | 2 | 1 | 1 | | | | 4 | 2.00 | 4.00 | 2 | | | | | | | 1999 |
| RECI | CV | 45.8500 | 25.9333 | 35TML17 | 548 | TSEC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 2000 |
| RETIŞU | SB | 46.0500 | 24.8500 | 35TLM30 | 465 | HIRT | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 1999 |
| RODBAV | BV | 45.9167 | 24.8667 | 35TLL38 | 474 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| ROŞIA SĂSEASCĂ | SB | 45.8167 | 24.3167 | 35TKL97 | 422 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | | | | 2000 |
| ROTBAV | BV | 45.8333 | 25.5500 | 35TLL87 | 509 | BIRS | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | | | 2 | | | | | 2000 |
| RUCĂR | BV | 45.8167 | 24.7667 | 35TLL27 | 402 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | 1 | | | | 2000 |
| RUPEA | BV | 46.0333 | 25.2167 | 35TLL69 | 471 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| RUŞCIORI | SB | 45.8167 | 24.0333 | 35TKL67 | 440 | SIBI | 1 | 1 | 1 | | | | | 1 | 1.00 | 1.00 | | | | | | | | 1996 |

Table 5. (continued)

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SĂCĂDATE | SB | 45.7667 | 24.3833 | 35TKL97 | 394 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | | | | 2000 |
| SĂCEL | SB | 45.7833 | 23.9333 | 34TGR27 | 516 | SIBI | 2 | 2 | 2 | | | | | 8 | 4.00 | 4.00 | 1 | | 1 | | | | | 2000 |
| SĂCELE | BV | 45.6167 | 25.6833 | 35TLL95 | 687 | BIRS | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 2 | | | | | 2000 |
| SACIOVA | CV | 45.7833 | 25.9500 | 35TML17 | 649 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 1997 |
| SADUL | SB | 45.6667 | 24.1833 | 35TKL86 | 637 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | | | | | | 2000 |
| SĂLIŞTE | SB | 45.7833 | 23.8833 | 34TGR27 | 607 | SIBI | 2 | 2 | 2 | | | | | 4 | 2.00 | 2.00 | 2 | | | | | | | 2000 |
| SÂMBĂTA DE JOS | BV | 45.8000 | 24.8167 | 35TLL37 | 426 | FAGA | 2 | 2 | 2 | | | | | 3 | 1.50 | 1.50 | | | 1 | | 1 | | | 1996 |
| SÂMBĂTA DE SUS | BV | 45.7500 | 24.8167 | 35TLL36 | 512 | FAGA | 7 | 7 | 7 | | | | | 25 | 3.57 | 3.57 | 3 | | | | 4 | | | 2000 |
| SÂNCRĂIENI | HR | 46.3000 | 25.8500 | 35TMM12 | 659 | CIUC | 4 | 3 | 1 | 2 | | | 1 | 5 | 1.67 | 5.00 | | 2 | | | 2 | | | 2000 |
| SÂNDOMINIC | HR | 46.5833 | 25.7833 | 35TMM05 | 757 | CIUC | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | | | 1 | | | | | 2000 |
| SÂNMARTIN | HR | 46.2667 | 25.9333 | 35TMM12 | 676 | CIUC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | 1 | | | | | | 2000 |
| SÂNPAUL | HR | 46.1833 | 25.3833 | 35TLM71 | 472 | HOMO | 18 | 18 | 15 | 3 | | | | 48 | 2.67 | 3.20 | 5 | 11 | 1 | 1 | | | | 2000 |
| SÂNPETRU | BV | 45.7167 | 25.6333 | 35TLL96 | 535 | BIRS | 3 | 2 | 2 | | | | 1 | 4 | 2.00 | 2.00 | | | 2 | 1 | | | | 1996 |
| SÂNSIMION | HR | 46.2500 | 25.8833 | 35TMM12 | 646 | CIUC | 27 | 27 | 24 | 3 | | | | 81 | 3.00 | 3.38 | 2 | 17 | | | 8 | | | 2000 |
| SÂNTIMBRU | HR | 46.2833 | 25.8667 | 35TMM12 | 652 | CIUC | 8 | 6 | 6 | | | | 2 | 22 | 3.67 | 3.67 | 3 | 2 | | | 3 | | | 2000 |
| SÂNTION LUNCA | CV | 45.8167 | 25.8667 | 35TML17 | 525 | TSEC | 5 | 5 | 5 | | | | | 15 | 3.00 | 3.00 | | 2 | | 1 | 2 | | | 2000 |
| SÂNZIENI | CV | 46.0500 | 26.1333 | 35TML39 | 593 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 1997 |
| SĂRATA | SB | 45.7333 | 24.5000 | 35TLL06 | 442 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | | | | 1996 |
| SĂSĂUŞI | SB | 45.8500 | 24.6000 | 35TLL18 | 567 | FAGA | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | | | | | | 1 | | 2000 |
| SATU NOU | BV | 45.7667 | 25.5167 | 35TLL86 | 517 | BIRS | 3 | 3 | 3 | | | | | 12 | 4.00 | 4.00 | | | 3 | | | | | 2000 |
| SATU NOU | HR | 46.1500 | 25.4000 | 35TLM71 | 507 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | 1 | | | | | | 2000 |
| SCOREI | SB | 45.7500 | 24.5333 | 35TLL06 | 450 | FAGA | 12 | 11 | 8 | 3 | | | 1 | 26 | 2.36 | 3.25 | 6 | | | | 5 | | | 2000 |
| SEBEŞUL DE JOS | SB | 45.6500 | 24.3333 | 35TKL95 | 507 | SIBI | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 2000 |
| SEBEŞUL DE SUS | SB | 45.6500 | 24.3500 | 35TKL95 | 489 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| ŞELIMBĂR | SB | 45.7667 | 24.2000 | 35TKL87 | 379 | SIBI | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| ŞELISTAT | BV | 45.9833 | 24.8500 | 35TLL39 | 567 | HIRT | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | 1 | | 1 | | | | | 2000 |
| ŞERCAIA | BV | 45.8500 | 25.1333 | 35TLL57 | 444 | FAGA | 6 | 5 | 5 | | | | 1 | 18 | 3.60 | 3.60 | 3 | | 3 | | | | | 2000 |
| ŞERCĂIŢA | BV | 45.7333 | 25.1167 | 35TLL56 | 538 | FAGA | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |

Table 5. (continued)

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SFÂNTU GHEORGHE | CV | 45.8667 | 25.7833 | 35TML07 | 510 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | 1 | | | | | 1998 |
| SIBIU | SB | 45.8000 | 24.1500 | 35TKL77 | 401 | SIBI | 6 | 6 | 6 | | | | | 17 | 2.83 | 2.83 | | | | | | | | 2000 |
| SICULENI | HR | 46.4167 | 25.7500 | 35TMM04 | 677 | CIUC | 11 | 8 | 7 | 1 | | 1 | 2 | 23 | 2.88 | 3.29 | 2 | 5 | | | 3 | 1 | | 2000 |
| ŞINCA VECHE | BV | 45.7667 | 25.1667 | 35TLL56 | 479 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| ŞOARŞ | BV | 45.9333 | 24.9167 | 35TLL38 | 488 | FAGA | 2 | 2 | 2 | | | | | 8 | 4.00 | 4.00 | 1 | | 1 | | | | | 2000 |
| ŞONA | BV | 45.8500 | 25.0500 | 35TLL47 | 430 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | 1 | | | | | | | 2000 |
| STUPINI | BV | 45.7000 | 25.5667 | 35TLL86 | 527 | BIRS | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | | | 1 | 1 | | | | 1996 |
| ŞUMULEU-CIUC | HR | 46.3833 | 25.8333 | 35TMM13 | 814 | CIUC | 1 | | | | | | 1 | | 0.00 | 0.00 | | | 1 | | | | | 2000 |
| ŞURA MARE | SB | 45.8500 | 24.1667 | 35TKL88 | 461 | SIBI | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| ŞURA MICĂ | SB | 45.8667 | 24.0667 | 35TKL78 | 402 | SIBI | 2 | 2 | 2 | | | | | 8 | 4.00 | 4.00 | | | | | | | | 2000 |
| SURCEA | CV | 45.8833 | 26.0833 | 35TML28 | 536 | TSEC | 2 | 2 | 1 | 1 | | | | 4 | 2.00 | 4.00 | 1 | | | | 1 | | | 2000 |
| SZASZFALU (LUNGA) | CV | 46.0167 | 26.2000 | 35TML39 | 562 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| TĂLIŞOARA | CV | 46.1000 | 25.5833 | 35TLM90 | 494 | BIRS | 3 | 2 | 1 | 1 | | | 1 | 4 | 2.00 | 4.00 | | | 3 | | | | | 2000 |
| TĂLMACIU | SB | 45.6500 | 24.2667 | 35TKL85 | 418 | SIBI | 2 | 2 | 1 | 1 | | | | 5 | 2.50 | 5.00 | 1 | | 1 | | | | | 2000 |
| TAMAŞFALĂU | CV | 45.8833 | 26.1167 | 35TML38 | 541 | TSEC | 2 | 2 | 2 | | | | | 5 | 2.50 | 2.50 | 2 | | | | | | | 2000 |
| TÂRGU SECUIESC | CV | 46.0000 | 26.1333 | 35TML39 | 570 | TSEC | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 2000 |
| TELECHIA | CV | 45.8666 | 26.0333 | 35TML27 | 534 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| TELIU | BV | 45.7000 | 25.8500 | 35TML16 | 622 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | 1 | | | | 1996 |
| TICUŞUL VECHI | BV | 45.9333 | 25.1000 | 35TLL58 | 485 | FAGA | 2 | 2 | 1 | 1 | | | | 2 | 1.00 | 2.00 | | | | | | | | 1999 |
| TINOASA | CV | 46.0000 | 26.1833 | 35TML39 | 560 | TSEC | 6 | 6 | 5 | 1 | | | | 15 | 2.50 | 3.00 | 4 | | | | 1 | 1 | | 2000 |
| TOARCLA | BV | 45.9000 | 24.7333 | 35TLL28 | 461 | FAGA | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| TODERIŢA | BV | 45.7833 | 25.0667 | 35TLL47 | 495 | FAGA | 4 | 4 | 4 | | | | | 10 | 2.50 | 2.50 | | | 1 | | 3 | | | 1996 |
| TOHANU NOU | BV | 45.5500 | 25.3833 | 35TLL74 | 719 | BIRS | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| TOHANU VECHI | BV | 45.5667 | 25.3667 | 35TLL74 | 705 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 1996 |
| TOPLIŢA-CIUC | HR | 46.3666 | 25.8000 | 35TMM03 | 673 | CIUC | 2 | 1 | 1 | | | | 1 | 3 | 3.00 | 3.00 | 2 | | | | | | | 2000 |
| ŢUFALĂU | CV | 45.8333 | 26.0167 | 35TML27 | 528 | TSEC | 3 | 3 | 2 | | 1 | | | 6 | 2.00 | 3.00 | 1 | 2 | | | | | | 2000 |
| TURIA | CV | 46.0167 | 26.1500 | 35TML39 | 616 | TSEC | 2 | 2 | 2 | | | | | 9 | 4.50 | 4.50 | | 2 | | | | | | 2000 |
| TURNU ROŞU | SB | 45.6333 | 24.3000 | 35TKL85 | 618 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | | | | 1 | | 2000 |

**Table 5. (continued)**

| Locality | County | Latitude | Longitude | UTM code | Altitude (m) | Region | H | HPa | HPm | HPo | HPx | HE | uH | JZG | JZa | JZm | Electric pylon | Pylon with | Chimney | Roof | Barn | Tree | Other | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUŞNAD | HR | 46.2167 | 25.9000 | 35TMM11 | 672 | CIUC | 6 | 6 | 6 | | | | | 22 | 3.67 | 3.67 | 1 | | | | 5 | | | 2000 |
| TUŞNADU NOU | HR | 46.2000 | 25.8833 | 35TMM11 | 655 | CIUC | 5 | 4 | 2 | 1 | 1 | | 1 | 6 | 1.50 | 3.00 | 1 | 3 | 1 | | | | | 2000 |
| UCEA DE JOS | BV | 45.7833 | 24.6667 | 35TLL17 | 425 | FAGA | 1 | | | | | | 1 | | 0.00 | 0.00 | 1 | | | | | | | 2000 |
| UCEA DE SUS | BV | 45.7500 | 24.6833 | 35TLL16 | 510 | FAGA | 2 | 1 | 1 | | | | 1 | 4 | 4.00 | 4.00 | 1 | | | | 1 | | | 2000 |
| UNGRA | BV | 45.9833 | 25.2667 | 35TLL69 | 457 | FAGA | 6 | 6 | 6 | | | | | 18 | 3.00 | 3.00 | 4 | | 2 | | | | | 2000 |
| VAD | BV | 45.7833 | 25.1333 | 35TLL57 | 475 | FAGA | 3 | 2 | 2 | | | | 1 | 6 | 3.00 | 3.00 | 1 | | | | 2 | | | 2000 |
| VALEA CRIŞULUI | CV | 45.9167 | 25.7833 | 35TML08 | 606 | TSEC | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 1999 |
| VALEA SEACĂ | CV | 46.0833 | 26.1166 | 35TMM30 | 622 | TSEC | 2 | 2 | | 1 | 1 | | | | 0.00 | 0.00 | 1 | 1 | | | | | | 2000 |
| VÂRD | SB | 45.9500 | 24.6000 | 35TLL19 | 489 | HIRT | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| VÂRGHIŞ | CV | 46.1333 | 25.5333 | 35TLM80 | 498 | BIRS | 2 | 2 | 2 | | | | | 7 | 3.50 | 3.50 | 1 | | 1 | | | | | 2000 |
| VENEŢIA | BV | 45.8667 | 25.2000 | 35TLL68 | 466 | FAGA | 12 | 11 | 10 | 1 | | | 1 | 33 | 3.00 | 3.30 | 4 | | 2 | | 6 | | | 2000 |
| VEŞTEM | SB | 45.7167 | 24.2333 | 35TKL86 | 366 | SIBI | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | 1 | | | | | 2000 |
| VICTORIA | BV | 45.7333 | 24.6833 | 35TLL16 | 541 | FAGA | 1 | 1 | 1 | | | | | 2 | 2.00 | 2.00 | | | 1 | | | | | 1996 |
| VISCRI | BV | 46.0500 | 25.0833 | 35TLM50 | 577 | HOMO | 1 | 1 | 1 | | | | | 1 | 1.00 | 1.00 | | | | | | | | 2000 |
| VIŞTEA DE JOS | BV | 45.7833 | 24.7333 | 35TLL27 | 443 | FAGA | 4 | 4 | 4 | | | | | 8 | 2.00 | 2.00 | 2 | | 2 | | | | | 1996 |
| VIŞTEA DE SUS | BV | 45.7333 | 24.7500 | 35TLL26 | 544 | FAGA | 1 | 1 | | | 1 | | | | 0.00 | 0.00 | 1 | | | | | | | 1999 |
| VLĂDENI | BV | 45.7667 | 25.3667 | 35TLL76 | 573 | BIRS | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 1996 |
| VLĂHIŢA NOUĂ | HR | 46.3500 | 25.5167 | 35TLM83 | 827 | HOMO | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | 1 | | | | | | | 2000 |
| VOILA | BV | 45.8167 | 24.8500 | 35TLL37 | 420 | FAGA | 3 | 3 | 3 | | | | | 9 | 3.00 | 3.00 | 1 | | 1 | | 1 | | | 1996 |
| VOIVODENII MARI | BV | 45.7833 | 24.8667 | 35TLL37 | 466 | FAGA | 1 | 1 | 1 | | | | | 3 | 3.00 | 3.00 | | | 1 | | | | | 2000 |
| VRABIA | HR | 46.2167 | 25.9167 | 35TMM11 | 655 | CIUC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 2000 |
| VULCAN | BV | 45.6333 | 25.4167 | 35TLL75 | 599 | BIRS | 3 | 3 | 3 | | | | | 6 | 2.00 | 2.00 | 1 | | 1 | | | 1 | | 2000 |
| VURPĂR | SB | 45.8000 | 24.3500 | 35TKL97 | 531 | HIRT | 1 | 1 | 1 | | | | | 5 | 5.00 | 5.00 | 1 | | | | | | | 2000 |
| ZĂBALA | CV | 45.9000 | 26.1833 | 35TML38 | 571 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | 1 | | | | | | | 2000 |
| ZĂLAN | CV | 45.9500 | 25.8167 | 35TML08 | 638 | TSEC | 1 | 1 | | 1 | | | | | 0.00 | 0.00 | | | | | 1 | | | 1997 |
| ZĂRNEŞTI | BV | 45.5500 | 25.3000 | 35TLL64 | 776 | BIRS | 4 | 4 | 4 | | | | | 8 | 2.00 | 2.00 | | | 3 | | 1 | | | 1996 |
| ZOLTAN | CV | 45.9333 | 25.8500 | 35TML18 | 553 | TSEC | 1 | 1 | 1 | | | | | 4 | 4.00 | 4.00 | | | | | 1 | | | 1999 |
| | | | | | | | **772** | **721** | **617** | **77** | **27** | **13** | **38** | **1965** | **2.883** | **3.338** | **234** | **86** | **159** | **30** | **173** | **18** | **7** | |

## Acknowledgements

We are grateful to Béldi Miklós, Molnár Lidia, Dr. Szabó József and Dénes Emese for providing some unpublished White Stork breeding data.

## References

Béldi, M. (1962): Háromszék (Románia) 1958. évi gólyakatasztere. *Aquila* 67-68: 204-206.

Burnhauser, A. (1983): Zur ökologischen Situation des Weiβstorchs in Bayern: Brutbestand, Biotopansprüche, Schutz und Möglichkeiten der Bestandserhaltung und -verbesserung. Abschlussbericht, Inst. f. Vogelk., Garm.-Partenk., 1-488.

Cătuneanu, I. (1999): Istoricul cercetărilor efectuate pe teritoriul României asupra migraţiei păsărilor prin metoda inelărilor, până la înfiinţarea Centralei Ornitologice Române, şi fazele acesteia de dezvoltare în perioada 1939-1970. Publicaţiile Societăţii Ornitologice Române, Nr. 8, Cluj-Napoca, 1999, 30

Chozas, P., Fernandez-Cruz, M. and Lazaro, E. (1989): 1984 National Census of the White Stork Ciconia ciconia in Spain. In: Rheinwald, G., Ogden, J. and Schulz, H.(1989): Weißstorch - White Stork - Proc. I Int. Stork Conserv. Symp., Schriftenreihe des DDA, 10: 29-40.

Damó, Gy. (1984): Datele privind efectivele de barză albă (Ciconia ciconia L.) din judeţul Covasna în anul 1984. *Aluta*, 16-17:344-349.

Damó, I. (1985): Efectivul berzelor albe (Ciconia ciconia) din judeţul Covasna în anul 1984. *Ocrot. nat. med. înconj.*, 29,(2), 145-148.

Damó, Gy. (1994): Kovászna megye gólyaállományának dinamikája. In: Németh, J. (ed.) (1994): Pro Natura, Kriterion, Bukarest, 132-138.

Demeter, L. (2001a): A Csíki-medencében folytatott gólyapopuláció-monitoring előzetes eredményei, *Collegium Biologicum*, 3, 39-45.

Demeter, L. (2001b): Connections between meadow habitats, White Stork and traditional agriculture in the Csík-basin (Eastern Transylvania) in a conservation perspective. Master of Science thesis, Department of Environmental Sciences and Policy, Central European University, Budapest.

Guziak, R., Jakubiec, Z. (1999): Der Weißstorch Ciconia ciconia in Polen im Jahr 1995 – Verbreitung, Bestand und Schutzstatus. In: Schulz, H. (ed.) (1999): Weiβstorch im Aufwind? – White Stork on the up? – Proceedings Internat. Symp. on the White Stork, Hamburg 1996. – NABU (Naturschutzbund Deutschland e.V.), Bonn: 171-187.

Klemm, W. (1969): Der Weiβstorch-Bestand im Gebiet von Sibiu (Hermannstadt) in Siebenbürgen 1963 und 1967. *Die Vogelwarte* 25,(1), 25-26.

Klemm, W. (1975a): Rezultatele recensămintelor de barză alba (Ciconia ciconia L.) în Ţara Bîrsei, Valea Hîrtibaciului şi Ţinutul Tîrnavelor. *Stud. şi Com. Şt. Nat., Muz. Brukenthal* 19:305-309.

Klemm, W. (1975b): Recensămîntul berzei albe (Ciconia ciconia L.) în împrejurimile Sibiului 1974. *Stud. şi Com. Şt. Nat., Muz. Brukenthal* 19:311-318.

Klemm, W. (1983): Zur Lage des Weiβstorchs (*Ciconia ciconia)* in der S. R. Rumänien. *Ökol. Vögel* 5: 283-293.
Klemm, W., Salmen, H. (1988): Die Ornis Siebenbürgens. Beitrage zu einer Monographie der Vogelwelt dieses Landes. Böhlau Verlag, Köln-Wien, Vol. III.:17-28.
Kohl, I. (1980): Madártani megfigyelések Hargita megyében. *Acta Hargitensia* 1:463-478.
Kovács, S. (1975): A fehér gólyák (Ciconia ciconia L.) fészkelése Kovászna megyében 1974-ben. *Aluta*, 6-7:479-485.
Kovács, Al. (1976): Cuibărirea berzei albe (Ciconia ciconia L.) în judeţul Covasna, în anul 1974. *Ocrot. nat. med. înconj*., 20,(1), 39-43.
Kováts, L. (1968a): A fehér gólya elterjedése Délkelet-Erdélyben 1962-63-ban. *Aquila* 75: 231-258.
Kováts, L. (1968b): Date asupra răspîndirii cocostîrcilor (Ciconia ciconia L.) în partea sud-estică a Transilvaniei. *Comunicări de zoologie*, 61-70.
Kováts, L. (1974): Ornitologische Beobachtungen im Salzgebiet von Sînpaul im Tale des Groβen Homorod. *Tibiscus*, Muz. Banatului, Timişoara, 129-140.
Kósa, F. (2001): Bestanderfassung des Weiβstorchs (Ciconia ciconia) in Rumänien im Jahr 1999. In: Kaatz, C. und Kaatz, M. (Eds.) (2001): 2. Jubiläumsband Weiβstorch – 2. Jubilee Edition White Stork, 8. u. 9. Storchentag 1999/2000. Tagungsbandreihe des Storchenhofes Loburg (Statliche Vogelschutzwarte im Landesamt für Umweltschutz Sachsen-Anhalt), 30-34.
Lakeberg, H. (1995): Zur Nahrungsökologie des Weiβstorchs Ciconia ciconia in Oberschwaben (S-Deutschland): Raum-Zeit-Nutzungsmuster, Nestlingsentwicklung und Territorialverhalten. *Ökologie der Vögel*, 17:1-87.
Lutsch, H. (1990): Situaţia cuibăritului berzei albe în judeţul Braşov 1990. *Bul. de inf. S.O.R.* (4).
Lutsch, H., Philippi, F. and Popa, Gh. (1990): Situaţia cuibăritului berzei albe în anul 1989 în judeţul Braşov. *Bul. de inf. S.O.R.* (3).
Molnár, L. (1979): Kovászna megye fehér gólya (Ciconia ciconia L.) állományának helyzete az 1978-as évben. *Aluta*, 10-11:421-434.
Molnár, L. (1981): Kovászna megye fehér gólya (Ciconia ciconia L.) állományának helyzete az 1980-as évben. *Aluta*, 12-13:407-414.
Molnár, L. (1990): Cuibăritul berzei albe în anul 1988 în judeţul Covasna. *Bul. de inf. S.O.R.* (3).
Philippi, F. (1997): Auf Wiedersehen, ihr Störche! In: Kaatz, C. und Kaatz, M. (Eds.) (1997): 4. und 5. Sachsen-Anhaltischer Storchentag, Tagungsbandreihe des Storchenhofes Loburg im MRLU-LSA, 18-20.
Philippi, F. (2001): Bestanderfassung des Weiβstorchs 1988-2000 im Kreis Hermannstadt (Sibiu – Rumänien). In: Kaatz, C. und Kaatz, M. (Eds.) (2001): 2. Jubiläumsband Weiβstorch – 2. Jubilee Edition White Stork, 8. u. 9. Storchentag 1999/2000. Tagungsbandreihe des Storchenhofes Loburg (Statliche Vogelschutzwarte im Landesamt für Umweltschutz Sachsen-Anhalt), 34-40.
Philippi, F., Popa, Gh. (1990): Situaţia cuibăritului berzelor în anul 1989 în judeţul Sibiu. *Bul. de inf. S.O.R.* (3).

Popa, Gh. (1983): Ergebnisse der Storchzählung (Ciconia ciconia) im "Alt-Land" (Mittellauf des Altflusses) in Siebenbürgen/Rumänien im Sommer 1982. *Arbeitkreis Weißstorch, DDR, Mitt.* Nr. 37, 1.

Radkiewicz, J. (1989): Der Weißstorch (Ciconia ciconia) im mittleren Westpolen 1984. In: Rheinwald, G., Ogden, J. and Schulz, H.(1989): Weißstorch – White Stork – Proc. I Int. Stork Conserv. Symp., Schriftenreihe des DDA, 10: 99-103.

Salmen, H. (1980): Die Ornis Siebenbürgens. Beitrage zu einer Monographie der Vogelwelt dieses Landes. Böhlau Verlag, Köln-Wien, Vol. I.:133-148.

Samusenko, I. (2000): *Preservation of White Stork (Ciconia ciconia L.) population on Belorusian Polessia*. MAB Young Scientist Research Project, Final Report.

Schulz, H. (1999a): The 5th International White Stork Census 1994/1995 – Preparation, realisation and methods. In: Schulz, H. (ed.) (1999): Weißstorch im Aufwind? – White Stork on the up? – Proceedings Internat. Symp. on the White Stork, Hamburg 1996. – NABU (Naturschutzbund Deutschland e.V.), Bonn: 39-48.

Schulz, H. (1999b): The world population of the White Stork (Ciconia ciconia) – Results of the 5th International White Stork Census 1994/95. In: Schulz, H. (ed.) (1999): Weißstorch im Aufwind? – White Stork on the up? – Proceedings Internat. Symp. on the White Stork, Hamburg 1996. – NABU (Naturschutzbund Deutschland e.V.), Bonn: 351-365.

Szabó, D.Z., Pap, P.L. (1996): Date privind recensămîntul berzei albe (Ciconia ciconia) în judeţul Harghita – 1995. *Milvus*, 3:19-20.

Tucker, G. M., Dixon, J. (1997): Agricultural and grassland habitats. In: G. M. Tucker and M. I. Evans (Eds.) (1997): *Habitats for birds in Europe: a conservation strategy for the wider environment*, Birdlife conservation series No. 6. Cambridge: BirdLife International, 267-325.

Tucker, G., Sanudo, P. F., Sastrei, P., Rebollo, J. C., Guillen, D. F. and Wascher, D. M. (2000): Environmental systems-Biodiversity. In: D. M. Wascher (Ed.) (2000): *Agri-environmental indicators for sustainable agriculture in Europe*, Tilburg: European Centre for Nature Conservation (ECNC technical report series), 97-146.

Ujvári, I. (1972): Geografia apelor României. Ed. Ştiinţifică, Bucureşti, 395-407.

Weber, P., Antal, L. (1978): Rezultatele recensămîntului de berze (Ciconia ciconia L.) din împrejurimile munţilor Harghita în anul 1973. *Stud. şi Com. Şt. Nat., Muz. Brukenthal* 22:393-402.

DR. FERENC KÓSA
„Babeş-Bolyai" University
Fac. of Biology and Geology
Cliniciilor Street, No. 5-7, 3400 Cluj, Romania
email: kosa@hasdeu.ubbcluj.ro

LÁSZLÓ DEMETER
Sapientia University
Faculty of Technical and Natural Sciences
Libertăţii Street, No. 1
4100 Miercurea-Ciuc, Romania

TAMÁS PAPP
Milvus Group
Călăraşilor Street, No. 5/7
4300, Târgu-Mureş
Romania

FRIEDRICH PHILIPPI
Spartacus Street, No. 14
2400 Sibiu
Romania

HANS-JOHANN LUTSCH
13 Decembrie Street, No. 113
2200 Braşov
Romania

KÁROLY GYÖRGY
Viitorului Street, No. 16
4000, Sfântu Gheorghe
Romania

# THE POLLUTION HISTORY OF THE MINING REGION OF NW-ROMANIA, A MULTIDISCIPLINARY PROJECT.

*Erhard Schulz, József Benedek, Sorina Fărcaş, Reiner Klemd, Uwe Schleichert, Wilfried Schreiber and Thomas Tittizer.*

**Abstract**

During the last three millennia the mining regions of northwestern Romania (Maramureş, Apuseni) exposed the processes of cultural landscape from the first openings to the intensive mining exploitation and pollution during the last centuries. In a joint research project colleagues of the universities of Würzburg and Cluj (Romania) and the Federal Institute of Hydrology (BFG) of Koblenz evaluate the natural (river sediments, peat bogs) and historical archives in order to establish a history of cultural landscape and pollution. Geomedical aspects also take a great part of these investigations. The first results evidenced the good resolution and information content of the archives and a regional differentiated mosaic of heavy metal contanimation. This also reveals long distance effects of heavy metal pollution and the actual risks for the drinking water supply of the regional population, as well as for the whole Tisa river system. The present health situation of the Maramureş population underlines these risks by the elevated incidences of professional diseases.

**Keywords:** Carpathians, Romania, Hungary, Tisa River system, mining, pollution history, geomedicine, risk assessment.

## Introduction

It was in January 2000 as the mining region of northwestern Romania got an enormous publicity by the nefarious cyanide spill of Baia Mare (Moran 2001). About 100000 $m^2$ of highly concentrated cyanide slurry was evacuated via the tributaries Săsar and Lăpuş into the rivers Someş and Tisa. This resulted into cyanide concentrations exceeding internationally accepted limits more than a thousand fold (VITUKI 2000).

About a month later an unsufficiently constructed dam of a tailing pond near Baia Borşa collapsed (Tittizer 2000). Consequently, the river Tisa was attacked twice. Once by the cyanide poisoning, which was diluted to less harmful values, only in the Danube river and parallely by the longtime pollution with heavy metals which could be stored in the rivers' sediments and finally may acummulate in the food chains. Especially the Upper Tisa was hit, since it was known before as a relatively less polluted river fulfilling the criteria of the Ramsar convention (Hamar and Sárkány-Kiss 1999).

In all there were three severe damages to the Tisa-Danube river systems in a short time, since in autumn 1999 the Pancevo bombings already caused severe poisonings downstreams, even if they were declared by NATO authorities as collateral damages.

Both accidents in 2000 could mobilize a great public. EU and UNDP deployed task forces to investigate and document the damages and to discuss and propose future prevention measurements (UNEP/OCHA 2000, Garvey 2000). EU represents as well as those from the national ministeries of environment announced a generous and longlasting aid and environment technique equipment of the regions concerned. At least these activities had the same fate as the cyanide flood. They got diluted, dissolved rapidly and afterwards they were hardy to detect anymore.

To get an idea about what planning measurements will be necessary in those regions in order to avoid further pollution and to get information on the ways of regeneration processes of the ecosystems it will be necessary to elucidate the historic evolution and the dimension of human impact.

Within a cooperation between the universities of Würzburg (Germany) and Cluj (Romania) and the Federal Institute of Hydrology (Koblenz, Germany) there is a common reserach project on the aspects of the longtime pollution of these mining regions and on the pollution development during the last millenia.

The area of investigation incorporates the most distal parts of the Pannonian (Someş-Lăpuş-) Plain and the mountain areas of Ţibles, Gutin, Maramureş (fig. 5) as well as the Apuseni-Mountains. The research is focussed on the present situation as well as it evaluates the natural (river sediments, peat bogs) and historical archives.

The following questions are the base of these investigation :

- which are the steps of the evolution of cultural landscape and of the intense exploitation of ressources?
- which are the consequences for the Tisa river system?
- which are the regeneration processes during periods of less intense exploitation?
- which are the consequences of the pollution on the health situation of the population?
- are there correlations between the mining history and the pollution levels in the sediments?
- which are the conclusions to be drawn from history for development possibilities and planning measurements to cope the negativ developments?

This article shall give the first results concerning the present situation and the background pollution.

## The region and ist present situation

The Maramureş and the Baia Mare region itself take part of the historical mining areas of Europe. For long periods mining activities were concentrated on gold and silver and it had its first activities in the time of the Hungarian Kingdom whereas the Apuseni Mts. were exploited already by the Romans and Dacians. During medieval time the richness of the Hungarian Kingdom was founded on these mining activities (Fischer and Gündisch 1999, Maghiar and Olteanu 1970, Schröker 1994, Szellemy 1984, Wollmann 1999 a-d). Today the same orebearing lodes in the volcanic and cristalline massives of the Inner Carpathians are still exploited. Uplands and High Mountains of these regions are also characterized by a diversified cultural landscape based on a long tradition of agriculture and forestry (Geografia Romanei 1987, 1992, Moisei et al 2000, Posea et al. 1980).

This resulted into a twofold landscape. For the one it is characterized by traditional agriculture and settlement (Maramureş) and for the other the numerous active or abandoned mines and smelters are typical for the Baia Mare region itself together with their tailing ponds and an accelerated pollution. Moreover, the security state of the several decantation basins is very low, so even the scandalously conceived and constructed "Aurul" tailing pond was considered as an improvement of security (UNEP/OCHA 2000). The lead smelter of Baia Mare (the present "Romplumb") became important during the last centuries, and the metallurgical complex „Phoenix" processes ores from the whole region including the Apuseni Mts. This results into a high charge of lead, copper and zink as dust or solutes coming from exploitation and from smelting processes being reinforced by the lamentable situation of the metallurgical plants during the last decennia. Even it would be naive to wait a less polluted environment, it is necessary to decide which extremes are to reduce or to buffer in order to arrive to minimum health and environment standards. It also points to the necessity of Hungary and Romania, to aline their legislation (and its realisation) to those of the European Community. In all, the situation underlines the immanent thread for the river system of Tisa and Danube.

## The local context- the town of Baia Mare

Urban planning of Baia Mare during the time of socialism was characterized by a forced industrialization and urbanisation, which was generally characteristic for the romanian society. That aggravated some negative evolution for the environment, such as the intense interfingering of industrial zones and residential areas, expecially the close neighbourhood of ore treatment plants and food processing factories. This is clearly shown in the town map of Baia Mare (fig. 1). Northeast of the town a steep valley harbours closely together the lead smelter „Romplumb" and the residential area "Ferneziu". The nearest houses already join the entrance of the factory. This neighbourhood naturally affected enormously the people´s health situation.

The mining and ore processing industry of the town is concentrated in the eastern part. The actual factory „Allied Deals Phoenix" was founded in 1907 as a chemical and sulfuric acid plant and in 1925 it was transformed into a metallurgical complex. During the socialist period it was enlarged and at present it represents 40 % of the Romanian non-iron metal production. Today 3400 persons are working at the "Phoenix" complex, which also is the larges employer in Baia Mare. The intense growing of that factory and the extension of the town to the East caused the present interfingering of residential quarters with metallurgical, food processing and ceramic plants, a fact which was inforced during the socialist period. The situation is even aggravated by the presence of several retailing ponds in the town itself: „Tautii de Sus" in the East, „Sasar" and especially „Meda" in the West. The already mentioned „Aurul" plant was conceived to treat the retailing pond „Meda" in the middle of residential areas. This pond had a load of about15 mio to material with an estimated content of 8 to gold and 50 to silver. Reclaiming should be combined with exploitation. A new pond for the remaining material was planned about 15 km west to the town.

Finally, in a „win-win" situation three parties should find advantages:

a. the population by the creation of about 200 new jobs;
b. the „Aurul" plant by the extraction of gold and silver;
c. the administration by the removal of an important source of pollution.

The plan failed out of insufficiant planning and a dangerous construction of the new pond resulting in the well-known cyanide spill (confer UNEP/OCHA 2000).

In all, the urban planning did not take into consideration the physical structure of the environment. This resulted into the classical basis for enormous pollutions:

- a relief of narrow side valleys leading to a large main valley with steep slopes facing to the West into the Pannonian plain. This relief provokes inversion situations since about 220-240 days per year there is calm. Frequent fog from the river and about 700 to 800 mm annual rainfall cause rapid precipitation of all pollutants and their incorporation into the soil;
- gases and dust from a rotten industry with no or insufficiant dustfilters are emitted into that depression. This incorporates about 4000 to $SO_2$, 650 to lead, 90 to zink and 80 to copper from the main sources „Phoenix", „Săsar", and „Romplumb". In the early 90ies „Phoenix" factory did erect a 340 m high chimney, which now distributes gases and dust over the town and the larger vicinity, depending on the winds direction. A comparable chimney was constructed recently for the „Romplumb" plant.

In addition, about 24 tons of sterile are deposited within the town or in the near vicinity (1996). This endangers principally the water supply of Baia Mare and its surroundings. The water provision for Baia Mare itself is assured by the Firiza reservoir, the villages on the countryside however still depend on the shallow wells.

Consequently the health situation is endangered in two ways. On the one side there are the classical professional or work related diseases and on the other side the creeping and immanent risks by unsafe tailing ponds.

## Professional diseases

Professional diseases are good indicators for the security of the production and for environmentally negative processes affecting the health situation of the population. Several problems arise by the evaluation of these diseases: access to data on the community level is difficult and the reliability of these data is uncertain.

However, the evolution of professional diseases during the last then years in Romania shows a rising morbidity. This depends more on accidents and registration mistakes, since after the political change the industrial capacity and production were largely diminished.

**Tab. 1 Incidences of professional diseases in Romania between 1989 and 1998 after the verified diagnoses (source: DSP, Direcţia de Sănătate Publică, Maramureş)**

| Diagnosis | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incidences on o/oooo of the population | **134,4** | **142,1** | **140,4** | **139,1** | **162,9** | **201,5** | **215,2** | **213,4** | **218,2** | **191,0** |
| General cases: | 1423 | 1470 | 1414 | 1506 | 1562 | 1875 | 2032 | 2038 | 2060 | 1828 |
| Silicosis | 413 | 502 | 405 | 611 | 586 | 795 | 782 | 605 | 581 | 735 |
| -Silicosis | 402 | 485 | 394 | 583 | 561 | 781 | 736 | 577 | 554 | 682 |
| -Silico- Tuberkulosis | 11 | 17 | 11 | 28 | 25 | 14 | 46 | 28 | 27 | 53 |
| Work related poisonings: | 536 | 400 | 425 | 405 | 419 | 362 | 362 | 355 | 392 | 336 |
| -by lead | 358 | 275 | 308 | 266 | 310 | 241 | 228 | 247 | 270 | 234 |
| -by carbon monoxide | 38 | 36 | 29 | 45 | 11 | 24 | 36 | 19 | 33 | 16 |
| Skin diseases | 200 | 208 | 293 | 74 | 78 | 143 | 174 | 156 | 90 | 65 |
| Asthma | 55 | 133 | 140 | 199 | 170 | 259 | 241 | 250 | 282 | 202 |
| Infectious diseases | 12 | 30 | 23 | 20 | 17 | 49 | 14 | 28 | 37 | 39 |
| Ulceration of the nasal septum | 26 | 16 | 17 | 19 | 11 | 8 | 40 | 13 | 1 | 13 |
| Raynaud-Syndrom | 21 | 27 | 14 | 11 | 21 | 16 | 57 | 121 | 121 | 100 |
| Eye affections | 28 | 37 | 13 | 11 | 6 | 4 | 6 | 9 | 2 | 5 |
| Work-related cancers | 4 | 0 | 0 | 1 | 6 | 5 | 0 | 5 | 3 | 3 |
| Deafness | 55 | 27 | 10 | 56 | 50 | 56 | 39 | 112 | 90 | 46 |
| Other professional diseases | 62 | 72 | 57 | 85 | 186 | 158 | 289 | 368 | 449 | 275 |

Tab. 1. reflects that silicoses, infectious diseases, eye affections and ulceration of the nasal septum generally increased. This was caused not only by the deterioration of working conditions but also by an ameliorated registration of diseases. Work-related deafness and affection of hearing, skin diseases and allergics were increasing too.

**Tab.2 Incidence of work-related diseases in the counties of Transylvania in 1998 (source DSP, Direcţia de Sănătate Publică Maramureş)**

| Counties (judet) | AB | BH | BN | BV | CJ | CV | HR | *MM* | MS | SM | SJ | SB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of incidences | 34 | 18 | 81 | 121 | 27 | 0 | 45 | **465** | 25 | 70 | 44 | 86 |
| % of the general number | 1,86 | 0,98 | 4,43 | 6,62 | 1,48 | 0 | 2,46 | **25,4** | 1,37 | 3,83 | 2,41 | 4,7 |
| Number of employees exposed x10000 | 2,15 | 3,64 | 1,92 | 3,58 | 2,53 | 0,74 | 0,75 | **1,17** | 2,30 | 2,81 | 0,78 | 2,63 |
| % of the genera number/RO | 2,25 | 3,80 | 2,01 | 3,74 | 2,64 | 0,77 | 0,78 | **1,22** | 2,4 | 2,94 | 0,82 | 2,75 |
| Incidences: o/oooo of people exposed | 158 | 49 | 421 | 338 | 107 | 0 | 601 | **3980** | 109 | 249 | 564 | 327 |
| Average of incidences/ RO | 191 | 191 | 191 | 191 | 191 | 191 | 191 | **191** | 191 | 191 | 191 | 191 |
| Differences o/oooo / RO | -33 | -142 | 230 | 147 | -84 | -191 | 410 | **3789** | -82 | 58 | 373 | 136 |
| Number of dispenseries | 7 | 10 | 2 | 8 | 13 | 2 | 3 | **17** | 7 | 6 | 3 | 7 |
| % of the general number/RO | 2,07 | 2,96 | 0,59 | 2,37 | 3,85 | 0,59 | 0,89 | **5,03** | 2,07 | 1,78 | 0,89 | 2,07 |

1 AB (Alba), 2 BH (Bihor), 3 BN (Bistriţa-Năsăud), 4 BV (Braşov), 5 CJ (Cluj), 6 CV (Covasna), 7 HR (Harghita), 8 MM (Maramureş), 9 MS (Mureş), 10 SM (Satu Mare), 11 SJ (Sălaj), 12 SB (Sibiu)

The numbers of incidences differ greatly between the departments of Transylvania. It is due to the different degree of urbanisation, the different branches of economy and industry, as well as the number of employees and the quality of medical treatment. It also shows the poor knowledge about risk and pollution, about the general obsolete state of production and technology, as well as about the unsufficient organization of technological processes.

The departments of Transylvania differ from the mean value of Romania. 50% of the departments show higher values including Maramureş with extreme ones. The Baia Mare region and its economic structure cause and direct the dimension of pollution. Even in this department the risk-exposed people are less numerous, it shows the highest number of incidences of all departments.

The pollution by $SO_2$ passes regularly the Romanian limits (CMA), also the concentrations of cadmium remain permanently on a high level. Acid rain is a well known phenomenon in the whole region. Also the technological improvement of the industry between 1992 and 1996 could not diminish the soil pollution by the numerous inherited environmental burdens.

The heavy metal pollution represents the main risk for the public health in Baia Mare, and lead stays for the most dangerous of these elements. It accumulates in the blood and bones and it has also negative consequences for the childrens cognitive development. There are some studies on the risks of lead pollution, however data prior to 1995 are not very convincing (internal information public health authority Cluj). Access to the results of studies, younger than 1995, is very difficult. This explains the poor transparency of public and private institutions and also it represents a serious problem for future studies. Useful investigations rely on the extrapolation of blood analyses of children. WHO conducted a study (cited after UNEP/OCHA 2000), which was focussed on the above-mentioned "Ferneziu" quarter in the vicinity of "Romplumb" factory. The transfer of these results to the whole town remains difficult. The charge of lead was measured to 0,532 mg/dl in adults and 0,633 mg/dl in children (the limit is 0.1 mg/dl for children and 0,2 mg/dl for adults). In 2000 the public health authority of Cluj made another investigation (Glasul Maramureşului,2000). This time it was carried out in the whole town and it was focussed on children of an age between 7 to 11, which allowed a spatial differentiation. The pollution rises from the western residential areas (0,15 mg/dl) to the historical center and the industrial quarters in the East (0,28 mg/dl) and further on to areas in the North- East (0,32 mg/dl). Again the "Ferneziu" quarter bears the greatest load with 0,77 mg/dl. The study underlines that 47,6 % of the children of Baia Mare of an age between 7 to 11 expose lead concentrations in their blood from 0,3 to 0,5 mg/dt and that 10% of the children have values of more than 0,7 mg/dl lead.

There is no comparative study on the air pollution by dust and carbon monoxide, even if they represent the main risk factors for the public health. It will be necessary to identify all the emission sources, to evaluate and finally to restore them. Only a technological reorganization of the industry or its general transformation and a new concept of the public health management will allow an amelioration of the health situation of the population of Baia Mare region.

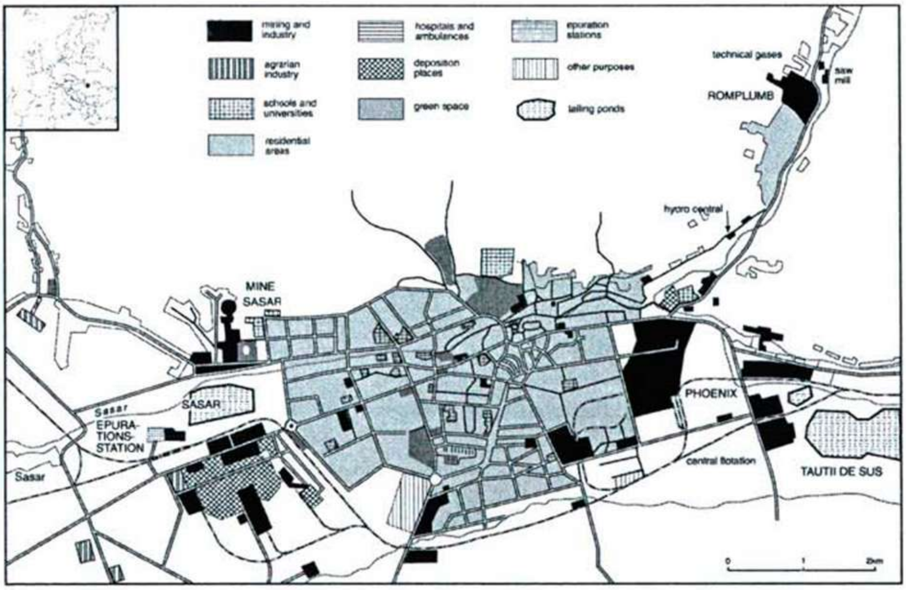



Fig. 1. Town- and land use map of Baia-Mare (Benedek and Molnar 2001, modified)

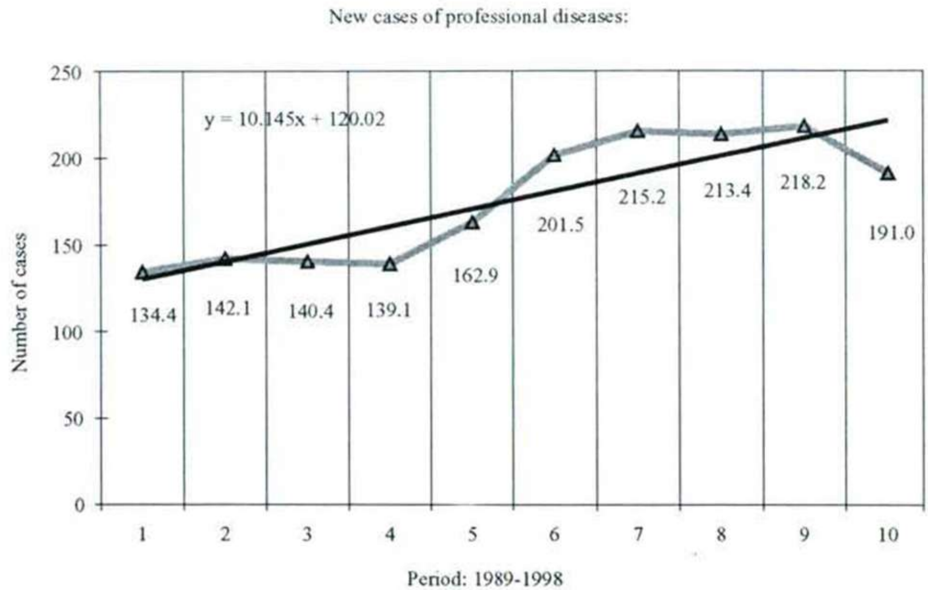



**Fig. 2. Incidence of work related diseases between 1989 and 1998 (Benedek and Molnar 2001, modified).**

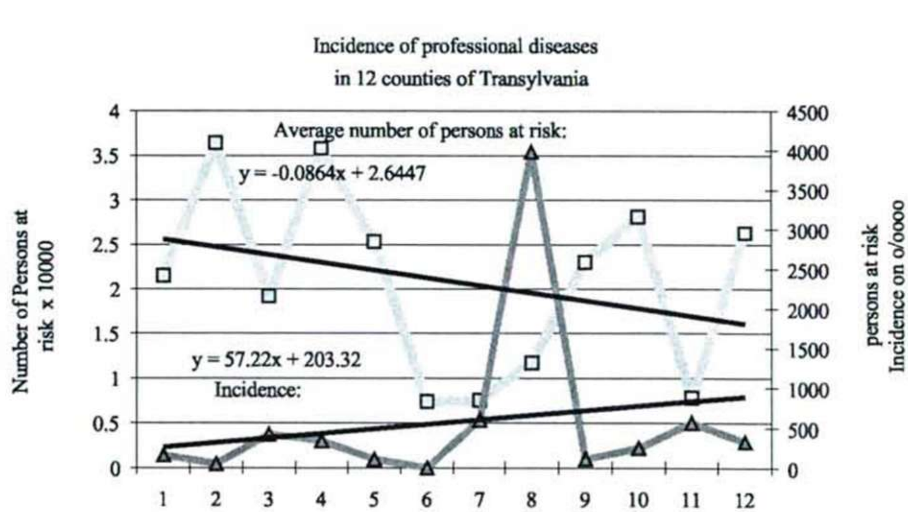



**Fig. 3. Incidence of professional diseases in the 12 counties of Transylvania. 8: Maramureş ( Benedek and Molnar 2001, modified)**

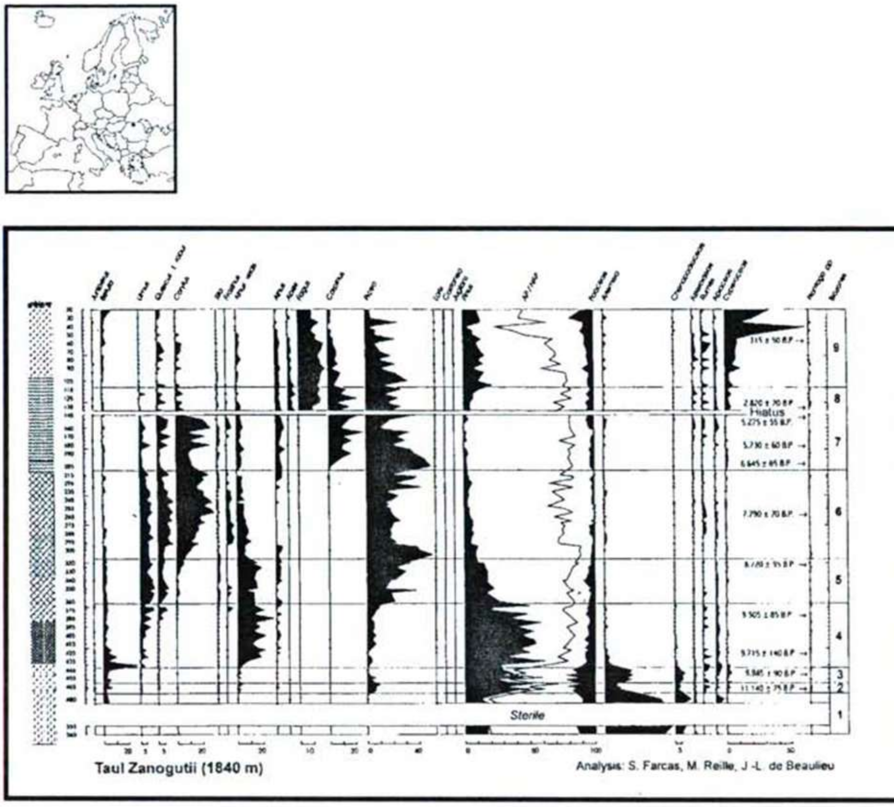



**Fig. 4 Pollendiagram from Tau Zanogutii, Southern Carpathians showing indicators of human interfirence during the last three millennia (Farcas et al. 2001).**

### The dust pollution in the regional context

The above described health situation in Baia Mare and studies connected to the „Aurul" and Baia Borşa-accidents (Hamar 2001, UNEP/OCHA 2000) evidenced a general high charge of lead, copper and zink in the region. These elements are also known as classical indicators for industrial activities (Fauth 1985, Harres et al 1987, Radtke et al. 1997).

If one wants to follow the evolution of pollution through the centuries and to detect periods of extreme pollutions and of regeneration it will be necessary to find the apropriate archives. They must allow a precise registration of the environmental situation and they must preserve these signals. Normally one would seek for meromictic lakes and peat bogs, whereas fluvial sediments are only of second order, since resedimentation is always included (Berglund 1965). Anyway, finegrained deposits from backwaters in the mouth of a tributary (like Lapus in Someş) may be useful since they were deposited calmly. Moreover the situation will allow that they register the charges of the whole catchment area.

Historical archives depict the extremely complicated mining history of this region (Maghiar and Olteanu 1977, Schröcker 1994, Wollmann 1999a-d). It is also illucidated in palynological investigations from the Apuseni and Gultai Mts. (Björkman et al. 2002, Bodnariuc et al. 2002, Farcas et al. 2000, Feurdean et al. 2001, Mitroescu et al. 1989). A pollen diagram from the southern rim of the inner Carpathians may explain the different phases of human impact on the forest composition in the relation of *Fagus, Picea, Pinus* and gramineae during the last 3000 years (Farcas et al. 2000). Comparable investigations were done in the Banatian Mts (Rösch and Fischer 2000). In this context it will be nescessary to investigate a great number of sequences to depict the dimension of forest exploitation and changes. A longlasting mining and metallurgical history also incorporates an intensive forest exploitation or an organized forestry. Wood was necessary for the mine constructions but for the greater part for the metal smelting itself (Thomasius 1994).

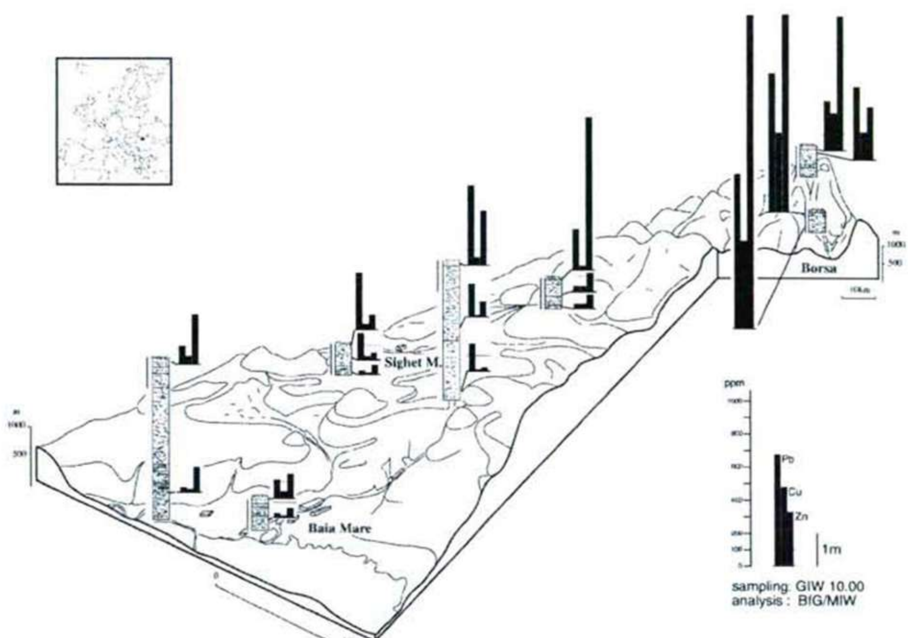



**Fig. 5 Blockdiagram of the Baia Mare und Borşa region also showing the coring (draft Schulz, cartography Wepler)**

Several peat bogs on the plateau between the Baia Mare and Maramureş depressions were cored in october 2000 as well as fluvial deposits in the direct vicinity of the „Aurul" pond and in the terrasses around the mouth of Lăpuş into Someş (Fig.5). The peat bogs on the plateau may capt the dust transported from westerly winds, whereas the fluvial sediments may register the complete situation of the catchment area.

The sediments were taken by a modified Livingston piston corer, respectively a Russian corer for the peat bogs. The complete section of finegrained material of the Lăpuş terrace was taken as well as the peat bogs could be cored down to the the technical limits. To get a further information on the actual pollution we also sampled the Vişeu River terrace at Bistra containing the load of the 2000 Baia Borşa spill (s.a.) and fine accumulations near Borşa and Baia Borşa. These terrasses only allowed short cores. Samples from the top of the cores and from various depths were analysed for their heavy metal content in the laboratories of the Federal Institute of Hydrology/ Koblenz and of the Mineralogical Institute of Würzburg university using a wavelengthdispersive x-ray fluorescence-spectrometry (Phillips PW 1410 at Würzburg) with a 10% or more accuracy. Because of the limited quantity the whole material was treated. This was to test whether the information content of the sediments was clearly differenciated along the core or whether it only was a mixture. Remarkable regional differences are visible in comparing the surface samples (fig. 5) and the heavy metal contents clearly diminish with the depth of the sequences. Lead, copper and zink are mentioned as the most important indicators in order to allow a comparison the the samples taken along the rivers Vişeu and Upper Tisa at the same time by colleagues from Szolnok and Cluj (Hamar 2001).

The two sediment cores from the distal Pannonian (Someş-Lăpuş) Plain show relatively moderate values even the EU limits are largely passed: lead 143/146, copper 60/39 zink 193/207 each in ppm (fig. 6). The enormous consumption of zink dust by the gold extraction process explains the fact that zink values pass those of lead. The sediments on the plateau at about 1000 m elevation show remarkable differences to those of the plain. Lead concentrations rise with a factor of two to four (447 / 267) whereas zink has elevated values (333/119) only in one peat bog, copper behaves comparable to the sediments from the Someş plain. If one looks to the results from the deeper sediments, it becomes clear that they diminish in the river plain and on the plateau to about 30 ppm for lead with the exception of the peat bog near Creasta Cocosului. Copper remains comparable in its values. Zink retains a concentration between 65 and 157 ppm. Investigation of peat bogs in the Apuseni Mts. also reported an elevated heavy metal-pollution (Mitroescu et al. 1989).

This demonstrated a general concentration of pollutants on the plateau since during west wind situations the dusts from the foreland is transported over the plateau. The heavy metal contents of the fluvial terraces of Baia Borşa and Borşa however arrive to totally different dimensions. Lead rises to concentrations of 939 and 308 ppm, zink climbs up to 1890 ppm also copper shows concentrations up to 538 ppm. These values are comparable to those reported from river terraces in old mining areas in Central Europe (Fauth et al 1987). For the Baia Borşa area it is easy to explain since it is the region of ore extraction. However the situation near Borşa is problematic since the local population relies to shallow wells for the water supply as it is the case in the Someş plain. Even if the accumulation of heavy metals in the top soil of forests and peat bogs is different (cf. Schulte and Blum 1997), and if the mobilisation of heavy metal dust from sediments into the ground water is to verify (Symader 1984), the level of all possible tolerances is largely passed. This results into an general thread which also explains the public health situation (s.a.).

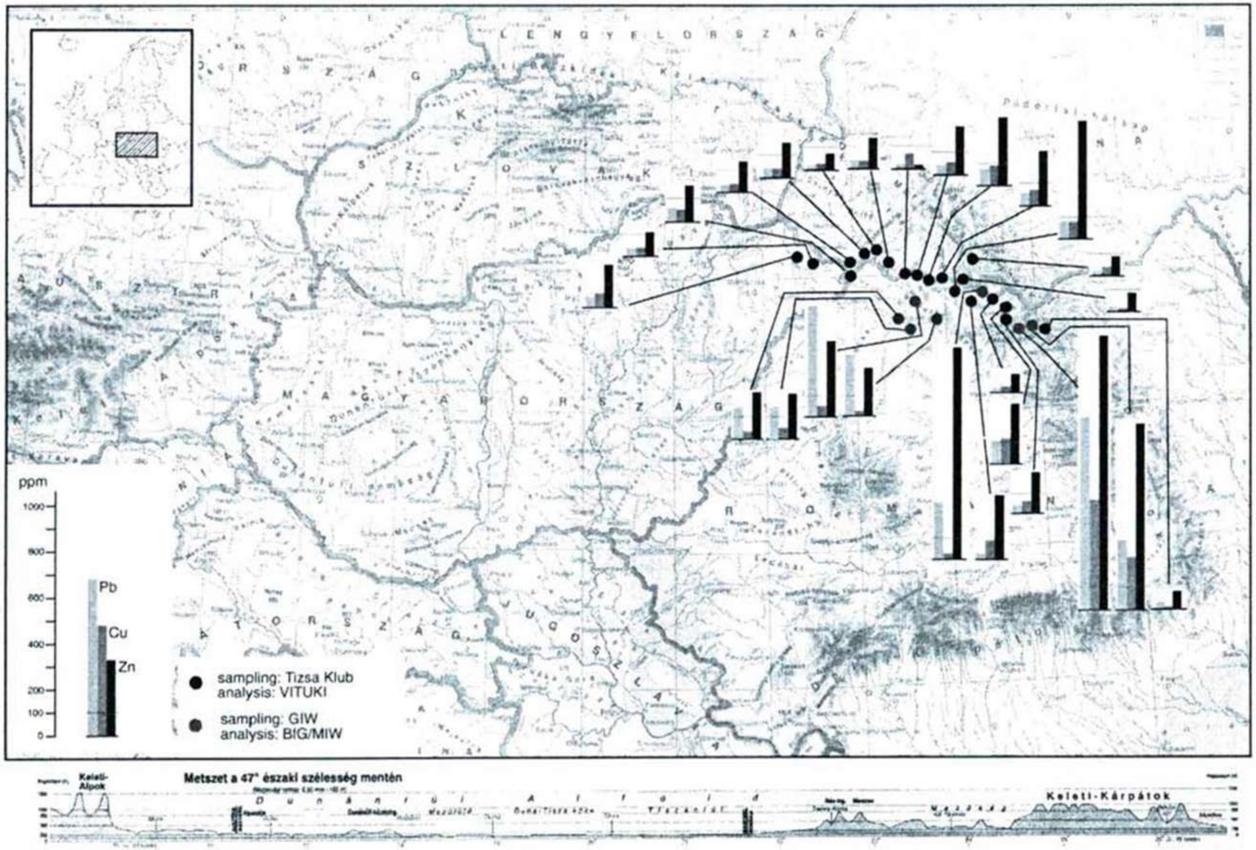
These heavy metal contents are generally higher than those reported in the geochemical atlas of Romania (IGR/BGR 2000, Sievers friendly communication) lead for example with a factor three. This may be due to he fact, that the surface sediments accumulated all dust deposits, whereas the river sediments themselves depict the respective actual condition of the transported material. There is also a large variety in space and in time. Copper and zink however show less pronounced differences.

A compilation of the results obtained on samples collected in october 2000 from the Würzburg group in the Pannonian Plain and on the plateau and from the Szolnok group along Vişeu and Upper Tisa (Hamar 2001) demonstrated the dillution effects along the Vişeu and Upper Tisa rivers, the differences between the plains and the plateaus, as well as the elevated values in the extraction zone of Borşa / Baia Borşa (fig. 6).

**The pollution background**

Parallel to the evaluation of the actual pollution the sediments cores already allow an estimation of the background pollution without a strong human influence. In this context one has to count with a lead concentration of 30 to 40 ppm, zink values between 60 and 170 ppm and those of copper af about 20 ppm. This stands for the Someş plain as well as for the plateau. The investigations on the Holocene sequence of Csaroda (NE-Hungary) also showed similar low concentrations of lead, copper and zink until the periods of intensive human impact (Sümegi 1999). The sediment core from the Viseau terrace behaves differently. Lead and copper have low concentrations only zink has values comparable to those of the Someş plain. There is no change with the depth. This may be caused by the sediment mixture during high floods in the steep valley different to the situation at the Lăpuş mouth in the Someş plain.

Fig. 6 Comparison of the actual heavy metal concentrations of surface sediments in the Baia Mara and Borşa regions and along the rivers Vişeu and Upper Tisa (after Hamar 2001 and own investigations, draft Schulz, cartography Wepler, topogr. Basis: Cartographia 1999)



## Conclusions

The first results of investigations of the present and past heavy metall pollution, in the Baia Mare region show the general good quality of the natural archives and clear differences in the contenst of heavy metals of the different sediments depending on the exposition or on extraction and dust deposition. It becomes clear that the present heavy metal concentrations on the peat bogs at about 1000 m elevation are two to three times higher than those of the Someş plain. The extremely high concentration in the settlement area near Borşa may be explained by the near distance to the ore extraction area however it represents a direct thread to human health, since the local water supply depends on shallow wells as it is the case for the villages in the Someş plain around the „Aurul“ pond too.

The present lead concentrations depass, with one exception, all the limits for soils, defined for Central Europe (cited from Harris et al. 1987). In the Borşa/ Baia Borşa region it also stands for copper and zink. The heavy metal concentrations decrease in the lower sediments in the plain as well as on the plateau beneath the above cited limits and so they may define the geological background pollution. Today the region has a generally elevated pollution background comparable to other mining areas (Faudt et al 1985, Harris et al 1987, IGR/BGR 2000). The threat for the public health however is inforced by the interfingering of metallurgical and food processing plants with residential areas. This is also explained by the comparison of the national and regional (Maramureş) health situation. In addition, there is the general thread of extreme damages caused by the insufficently protected inherited environmental burdens and by some scandalously conceived and constructed ore processing plants and their retailing ponds (cf. ICPDR 2000). This also represents an imminent danger for the whole Tisa River system.

## Aknowledgements

We are kindly indepted to the Geographical Institutes of Cluj and Würzburg and to the Sapientia Foundation for logistical and financial support. The contribution of Dr. Benedek is part of his Humboldt fellowships project.

## Zusammenfassung

Die Bergbaugebiete Nordwest-Rumäniens (Maramureş, Apuseni-Gebirge) zeigten über die letzten drei Jahrtausende exemplarisch die Prozesse der Kulturlandschaftsentwicklung von den ersten Öffnungen und Umstellungen der Landschaft zu intensiver Nutzung, den Regenerierungsphasen und der erneuten Nutzungsperioden seit der ungarischen Landnahme bis hin zu den intensiven Ausbeutungs- und Verschmutzungsphasen der letzten Jahrhunderte. Ein Kooperationsprojekt von Kollegen der Universitäten Würzburg, Klausenburg (Cluj, Romania) sowie der Bundesanstalt für Gewässerkunde Koblenz wertet die natürlichen

(Flusssedimente, Hochmoorablagerungen) und historischen Archive (Berichte, Karten) aus und bearbeitet dabei die Fragen nach den Etappen der Kulturlandschaftsentwicklung, nach den unterschiedlichen Dimensionen der Belastung innerhalb dieser Entwicklung, nach den Auswirkungen der Umweltverschmutzung auf die Gesundheit der Bevölkerung sowie nach möglichen raumplanerischen Maßnahmen zur Bewältigung dieser negativen Erbschaften.

Erste Ergebnisse zeigen einerseits die gute Auflösung und Reichhaltigkeit der Archive und andererseits das räumlich unterschiedliche Muster der Schwermetallbelastung. Insbesondere werden dabei neben den generell hohen Kontaminationen die starke Fernwirkung und die aktuelle Gefährdung der Trinkwasserversorgung der Bevölkerung in einigen Regionen sichtbar. Die aktuelle Gesundheitssituation des Kreises Maramureş belegt diese Gefährdung in der generell erhöhten Inzidenz von Berufserkrankungen.

## References


Benedek, J., Molnar, G. 2001: Die wirtschaftliche Situation in der Region Baia Mare und ihre Auswirkungen auf das Gesundheitsniveau der Bevölkerung, Petermanns Geographische Mitteilungen, 145, 3, 68-75.

Berglund, B.E. (ed.) 1986: Handbook of Holocene palaoecology and palaeohydrology. Wiley Interscience, Chichester, 869 p.

Björkman, L., Feurdean, A., Cinthio, K.-, Wohlfahrt, B., Possnert, G. 2002: Lateglacials and early Holocene vegetation development in the Gutaiului Mountains, northwestern Romania. Quarternary Sciences Reviews, 21, 1039-1059.

Bodnariuc, A., Bouchette, A., Dedoubat, J.J., Otto, T., Fontugne, M., Jalut, G. 2002: Holocene vegetational history of the Apuseni mountains, central Romania. Quarternary Sciences Reviews, 21, 1465-1488

Cartographia 1999. Középiskolai földrajzi atlasz, Budapest, 136 p

Farcas, S., de Beaulieu, J. - L., Reille, M., Coldea, G., Diacneasa, B, Goslar, T., Jull, T. 2000: First 14C-datings of Late Glacial and Holocene pollen sequences from the Carpathians, C.R. de l´Acad. Scien. Paris (Sc. vie et de la terre) 322, 7999-807

Fauth, H., Hindel, R., Siewers, U. Zinner, J. 1985: Geochemischer Atlas der Bundesrepublik Deutschland. BGR, Hannover, 79 p.

Feurdean, A., Björkman, L., Wolfarth, B. 2001: A palaeoecological reconstruction of the Late Glacial and Holocene based on multidisciplinary studies at Steregoiu site (Gutai Mts, NW Romania) Studia Univ. Babes-Bolyai, Geologia, XLVI, 2, 125-140

Fischer, H., Gündisch, K. 1999: Eine kleine Geschichte Ungarns, Suhrkamp, Frankfurt/Main, 302 p.

Garvey, Th. (ed.) 2000: Report of the international task force for assessing the Baia Mare accident, Bruxelles, 40 p.

Geografia României, 1987: Carpatii Românesti si Depresiunea Transilvaniei, III, Ed. Academiei, Bucuresti, 56-87 p.

Geografia României, 1992: Regiunile Pericarpatice, IV, Ed. Academiei, Bucuresti, 27-38 p.

Hamar, J. 2001: Heavy metal contamination of the Tisa river system, Tisa Klub, Szolnok, 16 p.
Hamar, J., Sárkány-Kiss, A. (eds.) 1999: The Upper Tisa valley. Tiscia monograph series, Szeged, 501 p.
Harres, H.P., Höllwarth, M, Seuffert, O. 1987: Altlasten besonderer Art. Erzgewinnung in Sardinien und Schwermetallbelastung. Eine Untersuchung am Beispiel des Riu Sa Duchessa. Geoökodynamik, 8, 1-48.
ICPDR. 2000: Regional inventory of potential accidental risk spots, Wien, 48 p
IGR/BGR. 2000: Geochemical atlas of Romania, Bukarest/Hannover. In Vorbereitung.
Maghiar, N., Olteanu, T.M. 1970: Din istoria mineritului în România, Ed. Stiintifica, Bucuresti, 252 p.
Mitroescu,S., Vadan,M, Dana, A. 1989: Studiul palinologic si geochimic al Tinoavelor de la Capatina-Muntii Apuseni. Contributii Bot. Cluj-Napoca, 149-165.
Moisei, F. (ed.) 2000: Muntii Maramureşului, Edit. Echim, Bukarest, 300 p.
Moran, R. 2001: More cyanide uncertainties. Lessons from the Baia Mare, Romania, spill-water quality and politics, Mineral Policy Center Issue Paper 3.
Posea, Gr., Moldovan, C., Posea, A. 1980: Judetul Maramureş. Ed. Academiei, Bucuresti, 180 p.
Radtke, U., Thönnessen, M., Gerlach, R. 1997: Die Schwermetallverteilung in Stadtböden, Geographische Rundschau, 49,10, 556-561.
Rösch, M., Fischer, U. E. 2000: A radioncarbon dated pollen profile from the Banat mountains (South eastern Carpathians, Romania), Flora, 195, 277-286.
Schröcke, H. 1994: Mining and german settlement in Slovakian historical summary. GeoJournal, 32,2, 127-135
Schulte, A., Blum, W.E.H. 1997: Schwermetalle in Waldökosystemen. In : Matschullat, J., Tobschall, H.J., Voigt, H.J. (eds) Geochemie und Umwelt, Springer, Berlin, 53-74.
Sümegi, P. 1999: Reconstruction of flora, soil and landscape evolution and human impact on the Bereg plain from late glacial up to the present, based on paleoecological analysis. In: Hamar, J., Sárkány-Kiss, A. (eds.) The Upper Tisa valley. Tiscia monograph series, Szeged, 173-204.
Symader, W. 1984: Raumzeitliches Verhalten gelöster und suspendierter Schwermetalle. Erdkundliches Wissen, 67, Steiner, Wiedbaden, 174 p.
Szellemy, G. 1894: Nagybányának és vidékének fémbányászata. Nagybánya, 45 p.
Thomasius, H. 1994: The influence of mining on woods and forstry in the Saxon Erzgebirge up to the beginning of the 19th century, GeoJournal, 32, 2, 103-125.
Tittizer, T. 2000: Dokumentation des Unfallortes "Klärteich Baia Borşa" am 16.3.2000, Koblenz
UNEP/OCHA (2000): Spill of liquid and suspended waste at the Aurul S.S. retreatment plant in Baia Mare, Geneva.
Vajda, L. (1981): Erdélyi bányák, kohók, emberek, századok. Politikai Könyvkiadó, Bukarest, 545 p.
VITUKI (2000): Evaluation of the impacts of the cyanide pollution, right during the passing of the pollution wave and immediately afterwards., Budapest, 6 p

Woditska I. (1896): A nagybányai m. kir. Bányaigazgatósági kerület monográfiája. Nagybánya, 74 p.

Wollmann, V. 1999a: Prähistorischer Bergbau in Siebebürgen. In: Slotta, R., Wollmann, V., Dordea, I. (eds): Silber und Salz in Siebenbürgen.. Veröffentlichungen aus dem Deutschen Bergbau- Museum Bochum, 85, 1, 19-23.

Wollmann, V. 1999b: Bergbau im römischen Dakien. In: Slotta, R., Wollmann, V., Dordea, I. (eds.) Silber und Salz in Siebenbürgen.. Veröffentlichungen aus dem Deutschen Bergbau- Museum Bochum, 85, 1, 24-34

Wollmann, V. 1999c: Der siebenbürgische Bergbau sei der ungarischen Landnahme. In . Slotta, R., Wollmann, V., Dordea, I. (eds.) Silber und Salz in Siebenbürgen. Veröffentlichungen aus dem Deutschen Bergbau- Museum Bochum, 85, 1, 35-40.

Wollmann, V. 1999d: Der siebenbürgisc he Bergbau im 18. Jahrhundert. In: Slotta, R., Wollmann, V., Dordea, I.(eds.). Silber und Salz in Siebenbürgen.. Veröffentlichungen aus dem Deutschen Bergbau- Museum Bochum, 85, 1, 41- 58.

Dr. József Benedek
Geographisches Institut
str. Clinicilor 5-7
3400 Cluj-Napoca
Romania
e-mail: jozsef@geografie.ubbcluj.ro

Dr. Sorina Fărcaş
Institute of Biological Research
Str. Republicii 48
3400 Cluj-Napoca
Romania
e-mail: ichmail.dntc.ro

Prof Dr. Reiner Klemd
Mineralogisches Institut
Am Hubland
97074 Würzburg
Germany
e-mail: reiner.klemd@mail.uni-wuerzburg.de

Dipl.Chem. Uwe Schleichert
Bundesanstalt für Gewässerkunde
Chemisches Labor
Am Mainzer Tor 1
56068 Koblenz
Germany
e-mail: schleichert@bafg.de

Dr. Erhard Schulz
Geographisches Institut
Am Hubland
97074 Würzburg
Germany
e-mail: erhard.schulz@mail.uni-wuerzburg.de

Dr. Wilfried Schreiber
Geographisches Institut
Str .Clinicilor 5-7
3400 Cluj-Napoca
Romania
e-mail: ameri@codec.ro

Prof. Dr. Thomas Tittizer
Mozartstr.
756154 Boppard-Buchholz
Tel: 076742-4043
e-mail:Thomas@tittizer.de

# THE MUREŞ CATCHMENT AREA NATURAL PARK

*Libus András †*

**Abstract**

The paper presents a short protection and research history of the Mureş Catchment Area Natural Park. The Park is localized downsteram of Arad town up to the Hungarian border. The characteristics ecosystems are steppe-type grasslands, meadow forests, swamps and marshes in different stages of eutrofication. Several species occuring here are listed in the appendix of the Bern Convention and the area is one of the Important Bird Areas (IBA) in Romania. The authors' conclusion is that in order to maintain biodiversity, concrete measures of protection and conservation are necessary in the Mureş catchment area.

**Keywords:** Mureş catchment area, biodiversity, protection

## Short history of the protection

The first approach to declare it a reservation was made in the year 1972, at the symposiums organized at Pecica and Arad by I. Moldovan and A. Ardelean.

In 1982, by the decision of the County Council, Lake Bezdin (24 ha) and Prudul Mare (16 ha) were declared Natural Reserves. In 1991 the reserve was increased to 91 ha. Paralelly, in Timiş County the Cenad Forest (314 ha) was put under protection. The foundation of the complex reserve "The Inferior Mureş Catchment Area" started in the year 1998 on the basis of the documentation of the Arad Environmental Protection Agency. The idea of the creation of the Mureş Catchment Area Natural Park was continued by the Forest Management of Arad, with the contribution of Head Manager Al. Priv and with the Phare CBC Project in the year 2001.

The project includes four components:

- the protecion of the area
- the creation of the visiting centre
- the monitorization of the ecosystems
- the promotion of tourism.

## Short history of the research

From a scientific point of view, the area has been the object of a few studies, made by L. Simonkai, I. Pop, A. Ardelean, C. Drăgulescu, I. Hodişan, Gh. Groza, Fl. Vulpe. The lepidopter fauna has been studied by Fr. König. During the last decades ornithological observations have been made by D. Lintia, E. Nadra, A. Sárkány, Z. Szombath et al., A. Libus. An international research team began a complex study on the river Mureş in the year 1991.

## Localization

The boundaries of the Inferior Mureş Catchment Area are: downstream the town of Arad up to the border with Hungary (approx. 75 river km). On its left and right banks it is bordered by the high loess terraces (major riverbed). The dykes built on the occasion of the regularization of the river border both banks. The holm area (minor riverbed) is 1-5 km broad.

## The description of the area

Downstream Arad the Mureş River has the characteristics of an inferior river course, forming numerous meanders and islands. Downstream Arad there lie meadow forests on a surface of 5819 ha, being under the administration of the Forest Department of Ceala. Beginning from 54 km downstream, the forest vegetation continues only on the left bank in the form of protection courtain (breadth: 50-100 m), up to the locality Cenad (Timiş county).

## Characteristic ecosystems

The steppe-type grasslands on loess, partly degraded, can be found on the steep slopes of the high terrace, on small surfaces. The indicator floristic elements are: *Festuca rupicola, Salvia austriaca* and *Adonis vernalis*. The meadow forests of the area are mainly natural riverside coppices, occupying about 15% of the total surface. Coppices with willows and poplars prevail, occupying the lower meadow areas, which are often flooded. Characteristic species are: *Salix alba, Populus alba* and *Populus nigra*. Lians are frequent: *Vitis silvestris, Clematis vitalba, Humulus lupulus*. In the recent years the adventitious species *Echinocystis lobata* has been invading. The coppices with oak-ashtree-elmtree in a natural state lie on smaller surfaces, in the higher meadow. Species of trees: *Quercus robur, Fraxinus angustifolia, Ulmus laevis, Acer campestris*. In the bush-layer the species *Cornus sanguineus, Euonymus europaeus* and *Crataegus monogyna* prevail. The grass layer is rich in the species: *Scilla bifolia, Anemone ranunculoides, Alliaria petiolata, Corydalis cava, Stachys* *silvestris*. Two species of orchids have been found: *Platanthera bifolia* and *Epipactis helleborine*. In the last few years small lots of oak-groves of saltings were identified (*Galatello-Quercetum roboris*) in whose clearings we can find the association *Peucedano-Asteretum sedifolii*, characteristic for soils in the course of salinization.

The wet zones from the Mureş catchment area lie on remarkably large surfaces. Mainly in the old deserted riverbeds we can find paludous vegetation, as well as along the dykes, where in the holes the water remaining after floods persists. These are swamps and marshes in different stages of eutrofication, with the pevailing species: *Phragmites australis, Typha angustifolia; Schoenoplectus lacustris*. Lake Bezdin is much more known, where water lilies can be found (*Nymaphaea alba, Nuphar luteum*) as well as species like *Salvinia natans, Utricularia sp., Sagittaria sagittifolia, Senecio paludosus*.

The forests in the minor riverbed are bordered by mesophyle meadows. From the fauna of the area we should mention the species that are present in the 3rd appendix of the Law nr. 236 as to protected natural areas, as well as in the Bern convention:

Mammals: 4 species

Birds: 72 species

Reptiles: 1 species

Amphibians: 6 species

Fish: 7 species.

Owing to the varied biotops and to the fact that the Mureş Valley is crossed by important routes of birds of passage, the Mureş Catchment Area is one of the Important Birdfaunistic Areas (IBA) of Europe. There are 44 IBAs in the country. 210 species of birds have been identified, among which about 100 species are breeding birds.

According to the IBA criteria, from the endangered species of the world 3 species are present in the area, which nested here a few decades ago: *Haliaetus albicilla* (white-tailed eagle), *Aythya nyroca* (ferruginous duck), *Crex crex* (corncrake). In a natural park it would be possible to stimulate their re-nesting.

From among the species endangered in Europe, there are 53 species to be found here, from which we mention a few nesting species: *Botaurus stellaris* (bittern), *Nycticorax nycticorax* (night heron), *Egretta garzetta* (little egret), *Pernis apivorus* (honey buzzard), *Milvus migrans* (black kite), *Aquila pomarina* (lesser spotted eagle), *Falco vespertinus* (red-footed falcon), *Coracias garrulus* (roller), *Sylvia nisoria* (barred warbler).

## Conclusions

In order to maintain biodiversity, concrete measures of protection and conservation are necessary in the Mureş catchment area.

## References

1. Monografia Simonkai - Flora comitatus et urbis Arad, 1893

2. D. Linția - Pasarile din R.P.R., vol. III., București, 1955

3. E. Nadra - Catalogul sistematic al colectiei ornitologice al Muzeului Banatului, Timisoara, 1972

4. V. Ciochia - Pasarile clocitoare din Romania, Ed. st. 1992

5. I. Hamar - A. Sarkany - Kiss - The Mureş River Valley, Szolnok, Tg. Mureş,1995

7. A. Ardelean, Fl. Dumescu, M. Covic - Rezervatiile naturale si monumentele naturii din judetul Arad, 2000

# IMPLICATIONS OF THE INTERDEPENDENCE OF HUMAN AND NATURAL ENVIRONMENT. CASE-STUDY OF THE RIVERINE POPULATIONS OF THE MUREŞ RIVER

*Veress Enikő*

**Abstract**

The implications of the human environment on the pollution of the ecosystem of the Mureş river are significant and the paper deals with the reactions of the human environment towards this theme and the possible solutions in order to prevent further pollution which could come from the inside of the local human communities alongside the river. The research reveals the directions we must emphasize in order to activate the local actors in the ecological activities.

**Keywords:** resource-dependency, local initiative, ecological education, punitive measures.

Alongside the history of mankind, the development of human communities was always dependent on the natural resources surrounding their settlement. People always settled down in the vicinity of a natural (mainly water) resource, this way they could ensure the premises in the construction of their households and the development of their local economy. Even if sometimes the river or the stream was not quite friendly to them, people always had returned after the floods and continued their lives in these places.

A new way of approaching the problems of the ecosystem of the river has determined us to expand our attention in this project to the possible consequences of the interdependence of the different elements of the ecosystem: the social environment of the river Mureş. The evolution of the resource-dependent human community was and is a traditional interest of the sociology of communities. The theme of resource-dependency resonates in both the early community studies and in the contemporary boomtown research studies from the nineties. In the research upon the Mureş riverine populations the emphasis was on the study of the other side of the relation between natural and social environment, that of the influence of the social community upon the surrounding natural environment.

Considering the importance of the interdependence of these two elements of the ecosystem, one cannot handle the problems of the sustainable development of the riverine communities alongside the Mureş without studying these aspects.

In order to make a broader analysis of these implications, we have made a research based on a complex methodology over the human communities alongside the stream of the Mureş to analyze the way the inhabitants relate to the vicinity of the river and the way this could influence the life and development of their settlements.

For a better grasp of the attitudes of the riverside population both quantitative and qualitative methods were used. So the first stage of the social analysis has started in the autumn of 1999 and included the qualitative research. The interviews made with the most important local actors (local authorities, schoolmasters, priests, top-managers in enterprises in the neighborhood of the Mureş, ferrymen, fishermen, private farmers) of the rural and urban establishments included in the sample gave us a broader view of the attitude of the community towards the actual situation and the possible variants of the development strongly influenced by the vicinity of the river. The close emotional link of these people to the river and their strong will to preserve the quality of the Mureş at least as it is now, and if possible even to improve it was the main finding of the interviews. The year 2000 has been the starting-point in the quantitative research, applied to a representative sample of 580 individuals (the number of questionnaires applied in a locality was determined by its demographic and economical potential).

I would like to make a brief presentation of the localities from the sample. In choosing the sample geographical location was taken into consideration, so we included in our pattern settlements from the upper-, middle- and lower reaches of the Mureş. Another condition in choosing the settlements from the sample was their economic potential and theway the economical life of the community influenced the actual quality of the river. This was certainly a relation of interdependence, as the vicinity to the river influenced the development of the rural as well as the urban settlements in the course of their history. And last but not least the demographic potential was as well important in the choice of the settlements' sample, so there were two small-size communities with a population below 4499 inhabitants (Sântimbru «including the villages of Sântimbru and Coşlariu», county of Alba and Ungheni, county of Mureş), two middle-size communities (Ciumani, county of Harghita and Vinţu de Jos «including Sântimbru and Vurpăr», county of Alba) with a population between 4500-9999 inhabitants and two large-size settlements (Aiud «including Aiud and the suburban Ciumbrud», county of Alba and Pecica, county of Arad), with a population of over 10.000 inhabitants. So there were in all nine settlements where the questionnaire was applied. This choice was made in relation to the territorial expansion of the flow of the Mureş River.

*Brief presentation of the human settlements included in the sample*

In the following I will try to shape the pattern of the settlements used in the social research, making a virtual excursion along the river of Mureş, making an incursion in the past of these settlings and showing the actual tendencies of the present development.

The first locality from our sample is **Ciumani**, in Hungarian Gyergyócsomafalva, from the county of Harghita, the closest settlement to the spring of the Mureş. It is situated in the upper reach of the Mureş, in the microregion of Gheorgheni, at an altitude of 745-770 m at the confluence of the streamlet of Nagy-Solymos and the Mureş. As an independent settlement it is mentioned from 1730 (before it had belonged to the village of Joseni- in Hung. Gyergyóalfalu- from the same county). Now it lies between Joseni (distance of 2 kilometers) and Suseni (3 kilometers). It is situated in the attraction-orbit of the greatest settlement of the region, the town of Gheorgheni (in Hungarian Gyergyószentmiklós) from the same county, at a distance of nine kilometers. The industrialisation from the communist era didn't bring a massive depopulation of the village of Ciumani in such a great measure, as the local active population had the possibility of commuting to Gheorgheni, where the need of labor-force snatched up the actives from the nearby villages, so from Ciumani, too (in 1991 41.0% of the actives were commuters). So the population from Ciumani did not suffer a massive depopulation in the communist era (at the census from 1992 its total population was of 4808 inhabitants. From the first census made on the basis of a real scientific methodology from 1880 until 1992 we can see that the population of the village had an upward development. From the data we have from 1996, the population shows a slow decrease in the nineties, mainly explainable with the international migration of the younger fertile population, but in the same time this is a feature of the third phase of the demographic transition which has reached in the last decades of the last century the countries from the Central and Eastern Europe as well.

Having a location which is hardly proper for agriculture (the average temperature is of 5°C, being one of the lowest from all over the country), the local population is forced to migrate in order to make their living. Its population was always known as being very skilled in carpentry, and even in the medieval monographies of the region, it is mentioned as being a feature in the local economy of the village. Another characteristic is the existence of more than 10 mineral wells, the historian Orbán Balázs in the 19$^{th}$ century mentioning that the local population uses only the water of these mineral wells and not that of the nearby brooks.

The vicinity of the Mureş river and the nearby streamlets had an influence upon the local economy, people trying to use the energy of water in their activities as an important source of income linked to the processing of the wood. So even from the 18$^{th}$ century there were water-sawing machines and even water-mills.

After 1989, the local economic situation could not escape the overall standing of the country. The downward tendency of the industrial development of the zone led to the disponibilisation of the commuting workers of the villages nearby. This is valid for Ciumani as well, where people could not perform a sustainable agriculture because of the natural conditions, and they tried to get involved in other sectors. So many of them (mainly the male population) commutes monthly - a very common way of migrating after 1989 - to other regions, mainly to Hungary, working as carpenters, mainly in the field of constructions.

One of the alternatives in the sustainable development of the village of Ciumani is considered to be local tourism (mainly rural and agro-tourism). The natural environment (the clear water and the closeness of the mountains and forests) and the cultural (historical, architectural and ethnographical) potential as well as the relatively good infrastructure and the lodging possibilities can make the village develop in this sector.

The local actors we have interviewed (the mayor, the history professor and the Roman-Catholic priest) were strongly convinced that the vicinity of the Mureş River has contributed to the development of this village, partly because the infrastructure has been developed from the 19$^{th}$ century as a consequence of the strategic location by the Mureş. The good quality of the river can contribute in the near future to the boom of the local tourism, so they consider that they have to preserve (at least) the actual ecological situation of the Mureş, not only because it can be one of the attraction-points, but also taking responsibility towards the forthcoming generations who will hopefully use the river in their leisure activities.

The next village from the sample is **Ungheni**, from the county of Mureş, located in the site of the river, which is called the Lunca Mureşului. Considered by the social geographist Vofkori László one of the most interesting zones of the river is one of the most important (both economically and demographically) micro-regions alongside the river. (Vofkori László,1999).This site includes one of the most important urban settlements alongside the Mureş River (Târgu Mureş-Hung. Marosvásárhely, German-Neumarkt am Miresch) and other seven communes located all on the course of the river (Maroskeresztúr, Marosszentanna, Nagyernye, Jedd, Marosszentkirály, Marosszentgyörgy, Ungheni-Nyárádtoe). This site is located on an area of 264 square kilometers, with a population of 199.619 inhabitants (data from the last national census from 1992).

**Ungheni (Hung. Nyárádtő)** is situated on the upper reach of the river, being one of the most important settlements in the county of Mureş, located at the confluence of the rivers of Mureş and Niraj. It has a favorable positioning, being located at a distance of only 10 kilometers from the county seat of Târgu Mureş (Hung. Marosvásárhely, Germ. Neumarkt), at an altitude of 296 m, one of the lowest places in the region. Ungheni is the administrative centre of the commune with the same name, commune which includes besides Ungheni, the following villages: Cerghid (H.Nagycserged), Cerghizel (Kiscserged), Săuşa (Sóspatak), Vidrăsău (Vidrátszeg) and Recea (Nagyrécse). In 1992 the commune had a population of 6609 inhabitants, Ungheni having a population of 3731 inhabitants. This settlement exists from the times of the Dacians, was an important locality in the Roman times, even now locals speak of the existence of a Roman road. Its strategic settling led along the history of the village to many good and bad things. Positive elements were thanked to the possibilities of a sustainable development of the local economy because of the vicinity of the water and the better development of the infrastructure (network of roads). The negative part in its history was due to the same elements: the vicinity of the river and the strategic importance of the village. This led to many distructions caused by the frequent floods of the river, and in the course of history was many times occupied along the military campaigns. It is a village with a multifunctional economy, fact being sustained by the existence alongside the agricultural activity of local industry: two water-mills on the river of Mureş and Niraj and a local distillation plant. The vicinity of the river and that of the city of Târgu Mureş has been of great help for the development of the village.

**Aiud (Hung. Nagyenyed, German Strassbourg)** is the only urban settlement of the sample, situated on the right side of the Mureş River, in the county of Alba at the contact of the Mountains of Trascău with the Plateau of the rivers of Târnava at an altitude of 270 meters. This settling assures the locality a very favorable resource in the development of an efficient agriculture, especially the wine-growing (its nobile wines are famous all over the country).

We have chosen two settlements from Aiud, one was that of Aiud and the other one was the suburban Ciumbrud, administratively subordinated to Aiud. The city of Aiud is positioned on a total surface of 624.157 hectares, site which includes the ten suburban localities which now administratively belong to Aiud. These ten localities are: Aiudul de Sus (Hung.: Felenyed), Gâmbaş (Hung.: Marosgombás), Măgina (Hung.: Muzsnaháza, Germ.: Mussendorf), Păgîda (Hung.: Kisapahida), Ciumbrud (Hung.: Maroscsombord), surface: 80,81 hectares, 1497 inhabitants, Sâncrai (Hung.- Enyedszentkirály), Gârbova de Jos (Hung.: Alsóorbó), Tifra, Gârbova de Sus (Hung.: Felsőorbó) and Gârboviţa (Hung.: Középorbó). At the census from 1992 the town of Aiud (including all the suburban localities) had a population of 24.731 inhabitants.

These settlements have existed from the Roman times, fact supported by the material proof of the nearby archeological site. In the 13$^{th}$ century Saxon settlers had built a fortress, the town maintaining its medieval characteristics even now.

The economy of the town influences the downstream quality of the water of the Mureş. So industry, developed mostly after the seventies in the process of the forced industrialization, has led to the pollution of the river. The hard industry, and especially the metallurgic plant and the concrete elements plant are the main sources of pollution for the Mureş. Even though after 1989 the economic situation has led to the decrease of the importance of the industrial sector in Aiud, the industrial sector still occupies 25% of the territory of the town.

As it is shown from the interviews made at the local council and at the Environment Protection Agency (EPA), the main purpose would be to rehabilitate the natural environment compromised by the unauthorised depositation of industrial garbage (mainly from the metallurgical plant), to punish the polluting sources and to bannish this kind of depositation. The local authorities (at least at the declarative level) are very keen on the finalization of the project of protection of the natural environment, but they complain beacuse of the shortage of financial resources.

The questionnaires applied in this town prove that the majority of the population is aware of the importance of the preservation of a proper environment, most of them complaining that there it is too little done by both the civil society and the local authorities.

There is still uncertainty among the respondents about the proper measures that must be taken in order to preserve an unpolluted environment, most of them expecting others (namely authorities, specialists) to do this.

**Sântimbru (hung. Marosszentimre)**, our next commune downstream the river Mureş is situated in the county of Alba, in the vicinity of the county seat Alba Iulia, at a distance of 8 kilometers. We have included two villages from this commune: the community center-Sântimbru and Coslariu, situated at 2 kilometers from the center. Having very favorable conditions, a soil of good quality and a good transportation infrastructure (roads as well as railway-station), Sântimbru is a village where the natural resources made the local development possible even during the communist period Small industry and services (transportation) has been an alternative in surviving even after 1989. The commune is one of the most prosperous one in the zone and the vicinity of the river of Mureş was and still is of great help in the maintenance of a socio-economic and demographic situation (in 1992 the population of the village has been of 1154 inhabitants, this meaning 43% of the whole commune's population).

Still with all this resource-dependence, by the interviews made by us with some local actors of the village of Sântimbru, we have realized that people seem not to be aware of the importance in the maintenance of a proper quality for the river has helped them throughout the history, waiting for "advice" from the authorities of the county of Alba and the central ones.

The next settlement of the sample is the village of **Vinţu de Jos (hung Alvinc, germ Unter-Winz, Winzendorf).** This commune is situated in the county of Alba at a distance of 12 kilometers from Alba Iulia, with a population of more than 8000 inhabitants. Besides the administrative center, the commune includes Sibişeni (hung. Sibisán), Inuri (hung. Borsómező), Vurpăr (hung. Borberek).

In our sample we have included two villages from this commune: Vinţu de Jos and Vurpăr.

Vinţu de Jos is a settlement with an impressive history. The actual settlement was built up by the Saxon settlers in the 12$^{th}$ century and now it is an important railway junction. Its historical and cultural potential (Vinţu de Jos has one of the nicest castles built on the place of an earlier Dominican monastery in the 17$^{th}$ century) can be a possible solution for the multifunctionalization of the local economy by the developing of tourism. Its good site and its developed infrastructure has led to the socio-demo-economic development of Vinţu de Jos, and besides the agricultural sector which is well developed here (the surroundings are known as having famous wineyards which produce wines of good quality as in the case of Aiud), small industry and services had developed along the settlement's history and even after 1989.

On the lower reach of the river is the village of **Pecica (hung. Marospécska),** situated in the countyof Arad at a distance of 20 kilometers from the county-seat, Arad. The commune of Pecica includes the following villages: Bodrogu Vechi (hung. Ó-Bodrog), Rovine (Hung. Magyarpécska), Pecica (Hung. Ó-pécska) and Turnu (Hung. Torony). It is the only villagein our sample which is situated in a plain, and probably is the most prosperuous village from our sample. The first proofs of the existence of a human community were found in the late neolithical age. In the Bronze Age, Pecica was the centre of a group ofsettlements, and because of the multitude of archeological sites which are different from all the rest, this was known as the Pecica-Periam culture (the most important vases are now in the Museum of the county seat). Because of its wonderful positioning,it has always been a flourishing settlement. Besides agriculture, the people from this village even from early medieval age (10$^{th}$ century) have used the water of the Mureş River for transportation. It is well known that the commerce with salt was a very profitable business and people even in the early 20$^{th}$ century used the Mureş as possibility for transportation of salt and for persons (people use even now the ferry for transportation). There were also water-mills which have functioned until the dawn of the communist regime.

In our interviews with the local actors (local catholic priest, teachers, local authorities, farmers and even two retired ferrymen) we could see the importance the local population attaches to the cohabitation with the river. Even though the latest floods (seventies, eighties) caused serious problems, the attachment of the community seems to be significant. The pollution of the river did not stop the locals, especially the young ones. It is an interesting initiative of a group of youngsters who would like to make a boat-trip upstream the river in order to see the geographical "history" of the Mureş.

After 1989 the situation of the community has not changed, one of the main functions of the local economy is still agriculture, which because of the fertile soil on the banks of the Mureş is an efficient activity. Still, it is not an intensive form of modern agriculture, but more an extensive one.

People with the help of the local authorities are trying to establish an activity of rural tourism, which would include the possibility of leisure activities related to the river of Mureş. The help of the central authorities (in the solving of the problems of the pollution of the river) keeps still waiting.

We must underline the interest shown by the locals in answering to questions regarding the actual natural ecological problems of the Mureş, caused mainly by the insufficiency of legislative frame in the ecological domain, so there are no efficient measures officialties can take in the punishment of those who pollute the water of the Mureş. In the findings od the social research we could see that there is- at the rhetoric-declarative level- a very strong attitude against those who are really responsible for the pollution of the river.

The presentation of the social research includes two subdivisions, the first relates to the existing links between the human population and the Mureş river and the second to the ways of the protection of the natural environment, particularly the Mureş river.

### A. Presentation of the sample

Our sample of the questionnaire, as mentioned above included 583 individuals, distributed as it follows in the nine settlements from the six communes of the sample:

**Table nr. 1: The numeric distribution of the sample for villages**

| Name of the settlement | Nr. of applied questionnaires | Percentual |
|---|---|---|
| Ciumani | 60 | 10.3 |
| Ungheni | 122 | 20.9 |
| Ciumbrud (Aiud) | 102 | 17.5 |
| Aiud | 14 | 2.4 |
| Sântimbru | 36 | 6.17 |
| Coşlariu (Sântimbru) | 44 | 7.5 |
| Vinţu de Jos | 54 | 9.26 |
| Vurpăr(Vinţu de Jos) | 33 | 5.6 |
| Pecica | 118 | 20.2 |
| Total | 583 | 100 |

The sample included settlements from the three reaches of the Mureş river, that is: the upper reach of the river is represented by the village of Ciumani (60 questionnaires) and settlements from the middle reach gave the 69,4% of the total, and the lower reach included only the village of Pecica (118). Our sample is representative for the whole population of the riverside as it includes all the economical, social and demographical categories which exist in the whole population, with a percentage close to the national census' data from 1992.

### The relation of the people to the river of Mureş

Personal identification items were followed by the questions which were ment to reveal the personal relation of the local people, especially with what finality do they use (if they use) the water of the Mureş. We will treat the relationship between the riverside human population and the Mureş as an input-output relation, input will include the way the population relates in its everyday especially economic – activity, the way they are protecting (if they do protect) the natural resources from their environment, particularly the Mureş river. So we wanted to find out how does the population handle the problem of removal of the organic and domestic trash.

The output side of the relation is represented by the activities related to the natural environment, household and leisure activities, so what the population "gains" from the fact of being in the close vicinity of a water resource. In parallel with the questionnaire we have interviewed older people who have made an oral history of the late few decades of the place the river used to have in the community's life. Our findings have revealed an existing close comunion of the riverside population with the Mureş and its resources.

In thw output we took into consideration more activities (agricultural, household and leisure) in which local people could have used the water or the ambience of the Mureş. We have also asked them if they drink (occasionally) from the water of the Mureş.

Results have shown that the great majority of the people never use the water of the Mureş for drinking (97,2%), the great majority has wells or running water (haven't got canalisation though). Only a small number of people specify that they do not drink because the water of the river is polluted. This is the case of those who live at a very small distance (50-150 meters from the banks of the river) and who used to drink the water of the river a few decades ago. The highest percentage of those who find the water of the Mureş handy and always drink from it are in Ungheni, county of Mureş, where they have an important colony of gypsies living close to the banks of the Mureş river, having no economical possibilities to dig to find a well or fountain. In many cases those who affirm that they do not use the water of the Mureş declare that even if they would not have this well (which in many cases hasn't got either the proper quality to be used as drinking water-see the case of Ciumani, Vinţu de Jos, Sântimbru where even the wells are infected because of the pollution from the industrial sites from the vicinity of these settlements) would not use the water of the Mureş because it is polluted and would bring (and in Vinţu de Jos they actually do) water for drinking from other sources-as in the case of Vințu de Jos- the spring of the Sibișel,the local population bringing in the drinking water with cars from almost ten kilometers. A similar case can be found in Sântimbru where the local doctor has affirmed that they have recently made bacteriological, chemical analysis of the water of the wells and they did not find one well which would correspond to the normal standards. The lady-doctor, although aware of the serious consequences has affirmed that: " what can one do? If hasn't got a horse, must go on foot!"

The more frequent use of the water of the Mureş in other activities can be seen in villages situated on the middle and lower reach of the river. People use the water especially in agricultural activities (watering and irrigating), although they have admitted that lately they rather use water from the well because the pollution from the water they have been using has caused serious damage to the crops (in the case of these people the most often asserted measure that must be taken in the near future would be the building of stronger dams and the ecologisation of the banks of the river). Of cause, the highest percentage of those who answer affirmatively to the question whether they use the water of the river in their activities is made up by the effective riverside population, with a distance of under 500 meters from the banks of the river. The existing positive correlation proves that our primary hypothesis regarding the role of the distance to the river in the development of a closer connection of the population with the Mureş proved to be right. At the whole sample this coefficient was r= 0,13, the highest values of these coefficients we could see in Ciumani (r=0,24) and in Pecica (r=0,29) where the distance plays an important part in the frequence of the use of the water of the river, especially in agricultural activities.

Another type of activity they use for the water of the Mureş are the household-activities. For now "only" the cleansing of the carpets and the washing of the (personal) cars, older women recall the period when they used to bring the clothes and washed it here. Even though they appear as different opinions, those who declare that the water is polluted and would not use it and those who never use it because they have other sources belong to the same category: that of the people who have an alternative to the water of the Mureş. A sad manifestation of the attitude of the people towards their personal role in the protection of the environment is that only a minor number of the respondents affirmed that they are not using the water of the Mureş in their activities because this way they themselves would pollute the river. The village where they declared in the highest proportion of the local sample that they would not use the water of the Mureş because they would pollute it is Ciumani, where these respondents form 10% of the local sample population (in the whole sample the percentage of those respondents who answer similarly is only of 1,88%!). These respondents have mentioned as a possible measure that must be taken in order to (re) establish the best possible quality of the Mureş the ecological education of the people, make them be aware of the results of their actions in the environment.

Another group of questions is still related to the output in the Mureş –human population's relationship, and these questions refer to the role this river plays in the leisure activities as well asin the ingestion of fish., meaning the size of the population from our sample who eat fish fished by the anglers (we could not find professional fishermen alongside the river).

Many people from our sample go elsewhere in their spare-timeT ey have confessed that in their youth (10-20 years ago-this is the cause of the age-groups which include the population between 40-60 years) they went frequently to the Mureş, but now they prefer other places (almost all of them prefer the mountains or neighbouring settlements where there is a water-spring where they can enjoy nature and in the same stay on the banks of a water-source (especially in the settlements downwards Târgu Mureş, in the middle and lower reaches of the river). Processing the information we could establish a positive correlation between the way people spend their free-time and the perceived quality of the Mureş (r=0,11). So those people who do not come to the Mureş in their leisure activities consider that the Mureş is polluted and in the same time dangerous, especially in the villages situated on the middle and lower reach of the Mureş people said that they are afraid for the life of their family, as the intensive exploitation of the river ballast caused serious damages in the bed of the river, and besides pollution the whirlpools from the river can be dangerous. Especially in the villages situated between Sântimbru and Pecica (including Pecica), one of the possibilities of making the Mureş more attractive for leisure activities was the establishment of a leisure center on the banks of the river (in an oral history an old man who used to be a ferry-man in Pecica narrated the possibilities that have existed in the thirties, when on the banks of the river there were more leisure centers, with open air bathes and lidos and tennis-courts for both the well-to-do social categories and the poorer ones could have had a very pleasant time). It is interesting what the younger (and poorer) people say, that going out to the banks of the river is the only opportunity to meet with friends without going to some pub in the village or nearby; and even if they admit that the conditions they find near the Mureş are many times terrible, they come here because they have no alternative in spending their free-time in the middle of the nature. In their case the attraction towards the Mureş is not the main argument they come here for.

Another possible way to spend one's free-time is to go out fishing (or more precise angling). From the whole sample only 17,3% of the respondents go or would like to go out angling. The overwhelming majority says that they never go out (90% Ciumani, 80% Pecica, 82.7% Ungheni), even if they did before, the main cause being the unexistence of fish. But people do not state affirmatively that they do not go out fishing because of the pollution .

People who are not anglers in their majority do not eat fish. The correlation of these two items gave a significant coefficient of r=0,21 for the whole sample, higher values being obtained in Vurpăr r=0,43, and Aiud r=0,38. There is no positive correlation between the quality of the water and the motivation of those who do not eat fish(so the quality of the water does not influence the people who do not eat fish) for the whole sample the value is r=-0,07, the only positive values being registered in Ciumani r=+0,28,

The following two questions reveal the input part of the relationship of the human and natural environment of the Mureş river, particularly how local people protect the Mureş from the individuals' pollution, this question can reveal the attitude the local riverside population shows towards the small-scale ecology which is dependant on their actions.

This category of questions was related to the handling of the removal of the rubbish, especially in those settlements where there is no institutionalised way of removing the trash. There were two questions in order to see how do the local people solve this very "thorny" problem each human community faces. We were aware of the fact that these people keep animals in order to supply the provisioning and work their household-plots (or their larger agricultural plots).

The great majority of the people use the organic trash (78,8% of those who have in their household such trash) as natural fertilizers and only 21,2% are placing it on the river banks or in dung-holes. In almost all of the settlements of the middle and lower reaches of the Mureş the dump-hole was in the close vicinity of the river (this was a place established by the local council sometimes decades ago) and people were very content with themselves as they were saying that they did nothing wrong just follow the "orders" of the authorities. Although in many cases they knew that this was not right they pleased oneselves that it was "legal" to do so. The only settlement where there was no such "authorised" dump was Coşlariu, but there were other ones used in common agreement by the locals.

Those who have responded that they do not have such organic trash have smaller animals (like poultry or pigs), so we can say that every household includes agricultural activities at small-autosubsistancy scale.

There were people who affirmed that one of the main problems is the discrepancy between the rhetorical and the real action-level, so many people who affirme that they throw away the dung from the animals "wherever they could, sometimes in twilight they went with the cart to the banks of the river and threw away the dung they did not use(the more serious problems appear when we talk about the removal and placing of the household garbage). There were just a few people who used the more and more popular storing method of the compost. The difference between them and those who affirmed that they have stored the trash in the garden was that the later were just putting the trash out without having a stable place where they used to put it. The great majority said that the back of the garden was the place they were putting the trash or they were throwing it directly on the land as natural fertilizers without any further storings of the dung.

Serious problems occur when we discuss the solutions the locals give to the removal of the household garbage, because almost all of the few settlements from the middle and lower reaches has a serious or more loose contract with a company which removes periodically of the rubbish, but people from Pecica, Vurpăr, Ciumbrud and Coşlariu are unhappy because of the defficiencies in the organisation of the removal, because for example in Pecica the rubbish is removed only once a month (!!) and in the meantime people have to handle themselves the transportation of the garbage. So as we can see, only the settlements downward Aiud benefit from an organised system of removal of the rubbish( the only exception is Pecica). Still even in these villages there is a significant percentage from the sample who cannot pay the fees of the removal (as they have confessed themselves), so they bury or incinerate (even the plastic is incinerated) the rubbish or in the case of the population from one of the

isolated districts from Vinţu de Jos (Intregalduri) they throw it on the banks of a streamlet which flows into the river of Mureş. A global evaluation of the current standings shows that in the case of 59,1% of the total sample population rubbish is removed from them or they are placing it in authorised (although not ecological) refuse dumps. Only 5.1% of the total population states that they throw the rubbish to the banks of the river. We had to register the responses the questioned persons gave so we could not verify the true/false quality of their affirmation.
The distance of the respondents to the river played a role in the placing of the garbage, even if with not a great significance, the evaluation of the data showed a positive correlation for the two items ($r = 0,04$).

One of the problems most people raised was the breaking of the promises by the local authorities, because on their electoral agenda at the 2000 local elections the placement of a better, more ecological refuse-dump or the punishment of the population who place garbage in forbidden places was included, but there are no encouraging signs in the direction of implementation of these objectives. Authorities have said that the complexity of this problem makes the functioning of such a projects not being visual at this moment, but they have mentioned that the people themselves should do something in order to marginalise those who really pollute the river by placing their household garbage close to the river in unauthorised places, particularly by public disapproval.
3.

This part of the research regards the way local people perceive the quality of the water and the possible solutions seen by the local population and the authorities to protect the Mureş and to avoid the further pollution of the river. This chapter includes the (subjective) perception of the sample population of the present condition of the river, the way authorities handle the environmental measures, the role population should play in the environmental actions and finally what chances do they see in the preservation of the natural environmental frame for the following generations and what specific measures should be taken in order to prevent further pollution of the Mureş.

We emphasize that this is the subjective perception of the local population on the quality of the water of the Mureş, the great majority affirming their judgements without any specific scientific basis, their opinion dictated in many times by their common-sense or by the negative personal Mureş-related experiences their neighbours or relatives just had

The question was referring to the perception of the quality of the water in the last few years related to its previous condition.

There is a very strong majority (63,1%) who is not content with the actual quality, most of them accuse the upper settlement who pollutes the river (see Ungheni accusing Târgu Mureş, Vinţu de Jos accusing Sântimbru and Pecica accusing Arad). There was a difference among the people who affirmed that the river is indeed polluted: there were those who were saying that for the whole year it is polluted, and others who connected it to the melting of the snow and the ecological accidents of one of its affluents: the Arieşul river. Those who said that the river is polluted in the whole year were those who when it came to the measures to be taken were the most fierce in aplying punitive measures against the pollution sources from the outside.

We can still find people who are making a distinction between pollution and muddiness, who are blaming that the balast-exploiting companies are to blame. These people have affirmed that the river is not so polluted but it is muddy and not good for drinking or bathing, but they have answered that the pollution has diminished after the industrial restructurations ofsome important polluters which have reduced after 1989 their production capacities. We might sarcastically say that this was the only benefit of the economic decrease to the population and to the environment. 14,7% of the sample population did not make any assertions related to the quality of the river. This is a very high percentage if we take into consideration the firm opinions of the population in previous questions.

Another important question in the population's reaction towards the activity of the authorities was related to the way local authorities handled the problem of pollution by taking measures in order to reduce it. Measures were considered to be: punitive measures against the polluters, a better placement for the refuse-dumps, the organisation of a guard who could watch out for the river and the duty of informing the hierarchical superiors about the more serious pollutions, etc.

The analysis of the responses reveals a very strong insatisfaction of the population towards the measures local authorities have taken until 2001. As the figures show, 73,0% of the whole sample considers that the local authorities did not anything or didtoo little in order to protect the natural resources. The percentage of those who are content with the way the local council and the mayorship handles the ecological problems is very low (12,1%), and it came from people who are still afraid to expose their opinions versus authorities because of the impregnated fear they have because criticism towards these institutions was not allowed and even seriously penalized. In our interviews made with representatives of the local authorities they have pointed out two main obstacles in the enactment of such projects: the impossibility of raising funds-we might add that sometimes we are facing the immobility of the local authorities and their lack of experience in competitions with a serious international financing and the lack of sympathy coming from the population, organised especially by those who have registered a loss lately in their relation to the local authorities.

Regarding the role people should play in the maintenance of a proper quality of the natural environment we have found a very interesting duplicity: even though 83,1% of the whole population admits that it is a moral duty of the locals to organise and participate at environmental projects in order to prevent the pollution of the Mureş, there were fewpeople who could come up with concrete actions that can be innitiated (and they would like to participate) and tell us more about the concrete ways this co-operation can come to action. So I believe that the opinions cover more the rhetorical level, many respondents want to correspond to the social expectations, "to say what must be said". Still there was a positive correlation (even if not very significant – $r = 0,1$) between the way people reacted to the possibility of co-operation and the concrete measures proposed by the same respondents. We must outline the role of educational level, which influences the way people feel about the importance of co-operation, educational attainment being a condition in the way they have responded (correlation coefficient was r = 0,1 for the whole sample).

With all this pledge to morality and co-operation, we must add that the lack of strong community bonds is something we did see along our observation sessions, so in the "rurban" communities, where modernity has distroyed the traditional community and did not bring in (yet) the postmodernity's civic society, there it is a sad reality that an incipient individualism associated with negligence characterizes the individuals' mentality. This is a serious obstacle in the probability of joint environmental actions of the population and the authorities.

The answers given to the question related to the future of the river's condition show that people are very pessimistic about the perspectives of the way pollution will evolve, a big exclamation mark must be put on the right side of the 27% of the absolute unbelievers in the improvement. If we want to draw into the community works the people in order to help in stopping the pollution, we must always be aware that there always be negativists, but sometimes ecological activists who are predicting a kind of world-wide catastrophy are more decise and can be more active. So we must not really see these people as totally unusable in ecological actions.

Figures show us that the optimism of the people is still there, a great percentage (45,8%) said that people can be educated. This can be a starting point but as our respondents have told us that the school and the other institutions must handle this problem it is obvious that they perceive thiseducation as being the task of "others" and they just enounce a way it must be done without very much intention of helping in one way or another in doing this. One of our respondents, an older woman from Vinţu de Jos has admitted that she cannot do anything: "even if I see those youngsters who are throwing all kinds of trash in the river, I cannot say anything or else they will beat me up".

There is a percentage of the people who believe that there is no need for any measures against those who pollute, because they already behave properly. Those who gave this response have lower expectations (mostly come for the lower strata of the social structure and have a lower educational attainment). Or they really cannot define the notion of "ecologically conscious behaviour", which is indeed very hard to define.

Our last question of the questionnaire was related to the way people see the possibility of taking into their hands the decision, the question sounded like this: "If you would be in position to make decisions for stopping the pollution of the river, what would you say?" this was an open question, meaning that the codes were set after recording all the 583 answers given by our respondents. Response variants were:

1. Has no opinion; 2. There is no need (satisfied). 3. Punitive measures towards all the polluting factors (men and industrial plants); 4. Education of the population; 5. The closing down of the external polluting sources (from outside the settlement); 6. The closing down of the internal polluting sources (from the settlement); 7. The control and the ecologisation of the river-bed; 8. Raising of funds for the cleaning of the water (especially external ones); 9. They have to control only the industrial plants; 10. The placement of waste-pipes/rubbish-shoot; 11. There is nothing to be done anymore.

The big number of the answering variants made possible to register a more nuanced view of the ecological measures to be taken asserted by the sample population. I have made up three groups of the proposed measures: 1. The group of the punitive measures which includes variants nr. 3.5,6 and 9. Differences are only those related to the extension of the punitive measures. 2. The group of the educational measures (variant nr.4). 3. The group of the constructive measures (variant nr.7 and nr. 10).

The great bulk of the people disapproves of the "softness" of the authorities when it comes to the punishment of the real polluting factors (mostly the industrial ones) as well as that of the individuals who are throwing away the trash in unauthorised places. If we take these three groups, we can say that the highest percentage was registered by the group of the "severe": 43,4%, followed by the "real measures" group with 29,1% and the education or "soft" measures had only 9,9%. The percentage of these groups varies for each settlement according to its geographical placement, so the settlements of Ciumani (56% punitive measures but in the same time 54% constructing measures), Ungheni 54,1%, Sântimbru (52% punitive measures), Vinţu de Jos (54% punitive measures) are situated in the closeness of pollution sources (big industrial centers like Târgu Mureş, Luduş, Alba Iulia, with the exception of Ciumani, where the respondents did not point to a specific pollution source). Punitive measures are seen by some of the respondents as the first step in order to restore a discipline which in their view cannot be done with only education. Many of them pointed out the lack of civic sense and the lack of self-discipline in actions. Those who believe in the force of education, point to the younger population which could benefit from a proper ecological education (there was a very negative opinioning towards the category of youngsters who have no ecological or other education, coming not only from the very old population). Although they agree that there is a strong moral crysis and school, among others is found responsible for this crysis, there is a belief that it could still fill up this function.

It is interesting to present the opinions of those who really want concrete measures: those who are for the placement of refuse-dump and waste-pipes or waste-filters or they want the local authorities to take greater measures and participate at greater zonal and regional projects of placing and strenghtening of dams and the regularisation of the river-beds. These measures in their great majority are for the increasing and improvement of the output the population can get from the river, in this case as in all it is the eternal economical relation between resource and needs. Needs like use of the water in agricultural activities but without having the constant fear that the river would flood every year and distroy their yearly work, other needs for using the Mureş as a leisure source (we have mentioned that the population has this claim of having - especially at the lower reaches of the Mureş river - leisure centers where people can spend their spare-time in confort). We can say that there is a positive environmental attitude towards the use of the Mureş, but this does not reflect the way each individual will act in everyday life.

Finally we can say that the social research has revealed two important things: that there is a consciousness towards the existence of pollution of the Mureş river, and this affects the riverside population, and on the rhetorical level there is a strong commitment for solving these problems with punitive and construction measures. On the other hand, there is no real support coming from the civil society in implementing such ecological projects and not even the environmentalist policies are very well seen as they affect the industry and besides the economical problems they create a social one: the unemployment. Romania has to realise that environmental policies include the creation of new jobs, and as it appears in the book *L'ecologie contre le chomage* edited by the organisation Les amis de la Terre in 1984 long-term employment will be possible for the local economy, first of all in order to repair the damages done until now to the natural environment, so we can say that ecology can be infiltrated in the economical process as a part of the producation process.

## Appendix

**Questionnaire (model)**

**A. The geographical localization of the studied settlement**

**1.The name of the settlement**

..............................................................

**2. On what reach of the Mureş River is it situated:**

1. lower reaches
2. middle reaches
3. upper reaches

**B. Identification questions of the subject**

**1. Gender:**
1. Male
2. Female
0. No answer

**2. Age:**
1. 0-19 years
2. 20-29 years
3. 30-39 years
4. 40-49 years
5. 50-59 years
6. 60-69 years
7. Over 70 years
0. No answer

**3. Marital status**
1. Unmarried
2. Married
3. Widow
4. Divorced
5. Concubinage
0. No answer

**4. Educational level**
1. Public elementary school
2. Vocational school
3. Training college
4. Secondary school
5. Post-secondary training
6. Higher educational training
7. No schooling
0. No answer

**5. Profession:**
1. Homemaker
2. Farmer (private)
3. Blue-collar
4. Official (clerk)
5. Professional
6. Private entrepreneur
7. Student, pupil
8. Unemployed
9. Pensioner
10. No profession
0. No answer

**6. Working place:**
1. Has no working place
2. Does not work anymore/yet
3. Works in the village
4. Works in a nearby rural settlement
5. Works in an urban settlement
0. No answer.

**7. Nationality:**
1. Romanian

2. Hungarian
3. Gypsy
4. German
5. Other nationality
0. No answer
**8. Place of birth:**
1. in the settlement
2. in a nearby village or city alongside the Mureş River
3. settlement from another region
4. No answer
**9. The period of your presence in this settlement:**
1. I was born here
2. We got settled from my childhood
3. I came here because of my profession
4. I came here after my marriage
5. I have come here recently
0. No answer

**C. Questions related to the environment**

**1. The distance of your house from the river:**
1. 0-5 m
2. 6-50 m
3. 51-100 m
4. 101-500 m
5. More than 500 m
*0. No answer*
**2. Do you use the water of the Mureş for drinking?**
1. Always because it is close and handy
2. Sometimes yes
3. Never because it is polluted
4. Never, because we have wells/fountains
0. No answer
**3. Do you use the water of the Mureş River in your household activities (watering, washing, carpet- cleaning, etc.)?**
1. Always, because it is by me
2. Not so frequently, but I use it
3. Never because it is polluted
4. No, because this way I would pollute the environment myself
5. No because we have running water and/or well from another source
0. No answer
**4. Where do you put the organic trash (animals, etc.)?**
1. We don't have such type of trash
2. We store it in the garden (for agricultural use)
3. We put in the garden and afterwards take it out to the land (fertilizer)
4. Compost
5. Throw it to the banks of the river
6. Garbage heap/dung-hole
0. No response
**5. Where do you throw the trash (in case you do not use it for heating-corn-cob f.e.)?**
1. Rubbish-shoot
2. Incineration
3. Garbage heap
4. Garbage heap and incineration
5. Throw to the banks of the river
6. Throw to the banks of the river and incinerate
7. Bury in the ground
0. No answer
**6. How often do you go in your spare time to the Mureş ( to take a bath, entertainment)?**
1. as often as we can (every weekend)
2. we prefer other places where we enjoy it more, but sometimes yes
3. never because it is polluted

4. we never go out
0. no answer
**7. Do you go fishing in your spare time?**
1. never
2. not lately because the water is polluted
3. I would like to, but I do not have time
4. As many times as I can, alone or with my friends
5. Sometimes
0. No answer
**8. How often do you eat fish from the Mureş River (even if it was fished out by someone else)?**
1. I never eat fish
2. Once in two months
3. Monthly
4. Weekly
5. More than once a week
6. Occasionally, but not very often
**9. If you do not eat fish, what is the motive?**
1. We were not used to in the family
2. I don't like fish
3. I do not eat it, because I cannot prepare it
4. I don't eat fish because the water of the river is polluted
5. I eat fish
0. No answer
**10. What is your opinion on the recent quality of the river Mureş?**
1. It has not changed, it is the same as it used to be, but it is polluted
2. It is worse than before
3. It is better than before
4. I cannot appreciate it
0. No answer
**11. How do you value the local official measures in the field protection of environment?**
1. There are no such measures in our settlement
2. There are some, but there are not efficient
3. I find them satisfactory at local level
4. In the actual economic situation there is too much talk about it
5. Cannot appreciate
0. No answer
**12. Do you think that in your locality there must be an active co-operation between the local authorities and the population in order to activate the protection of environment?**
1. No because there are far more important things we must solve at local level.
2. Maybe in another economic context, but now it is not efficient because there are no funds for sustaining it.
3. Yes, because we have the moral duty to preserve for the next generations an unpolluted environment.
**13. In your opinion what are the chances that the actual grown-up generation would leave an environment without polluting it?**
1. In this rhythm in a few decades everything will be deteriorated.
2. If we can make the people realise the consequences of the unprotection of the environment we can stop the deterioration.
3. The great bulk of the population contributes already to the protection of the environment.
4. I cannot estimate.
0. No answer
**14. What are the necessary measures coming from the local authorities for the improvement of the quality of the Mureş River?**
1. There is no need for such measures (satisfied)
2. Has no opinion
3. Punitive measures towards all the polluting factors (men and industrial plants)
4. Education of the population

5. The closing down of the external polluting sources (from outside the settlement)
6. The closing down of the internal polluting sources (from the settlement)
7. The control and the ecologisation of the river-bed
8. Raising of funds for the cleaning of the water (especially external ones)
9. They have to control only the industrial plants
10. The placement of waste-pipes/rubbish-shoot
11. There is nothing to be done anymore
0. No answer

## References

L'ecologie contre le chomage (Ecology against unemployment),(1984), Rome.

Vofkori László (1999): A Székelyföld leírása (The description of the Szekler's Land), vol.I., Budapest.

Recensamântul populatiei si a cladirilor din 1992 (the census of the population and of the households from 1992), CNS, Bucuresti.

ENIKŐ VERESS
Faculty of Sociology and Social Work
Babes-Bolyai University
1 Kogălniceanu
Cluj, 3400, RO

# CONTENT

B 198430

SZTE Egyetemi Könyvtár SZEGED 3.